BUSINESS PLAN

ISO/TC 266
Biomimetics

EXECUTIVE SUMMARY

Biomimetics combine the disciplines of biology and technology or other fields of innovation with the goal of solving practical problems through the abstraction, transfer, and application of knowledge gained from biological systems by interdisciplinary cooperation. This can give rise to many new innovations which in the past have often proved to be sustainable and economically efficient. Therefore, an increasing number of products, processes, patents and related events have evolved especially since the year 2000.

Despite this success not all products derived from such approaches are made visible and vice versa on occasions the terms “bionic” or “biomimetic” are used for products where no biomimetic approach can be found. This uncertainty needs to be resolved for legal as well as quality assurance aspects.

New standards are expected to contribute to the overall acceptance of biomimetic new or optimized products. Such products have potential to boost important aspects such as sustainability, business opportunities or legal issues, all for the benefit of the product’s producers and their respective customers. In this context sustainability is leveraged due to increased environmental compatibility as a result of reduced resource consumption and emissions. If these benefits are widely accepted also as means of standards, then companies may find easier access to new products and new markets based on these products and can thus derive appropriate long-term business strategies. It goes without saying that standards for biomimetics will also help both, producers as well as consumers of biomimetic products, rely on a legal foundation e.g. in regards to product liability. In cases where no products but methods are involved, standards will give rise to clear distinction of what biomimetics includes and what it does not include. Moreover, it is expected that standards in biomimetics will help prepare for the next technological leap.

Objectives of the ISO/TC are the development of international standards regarding terminology, advanced materials and biomimetic optimization. In this context, terminology will be standardized for clear distinction between biomimetics and conventional products and processes. Another standard will be concerned with biomimetic methods, structures and materials describing the transfer of biological principles into technical applications. A third standard will include biomimetic structure optimization. Guidelines developed by the Association of German Engineers (VDI) for various fields in biomimetics will be used as a seed point for the development of these standards.

As the development of these three standards are the highest priority, the ISO/TC will be organized in three working groups, each concerned with development of one of the according standards. Further standards might be developed in the future.

1 INTRODUCTION

1.1 ISO technical committees and business planning

The extension of formal business planning to ISO Technical Committees (ISO/TCs) is an important measure which forms part of a major review of business. The aim is to align the ISO work programme with expressed business environment needs and trends and to allow ISO/TCs to prioritize among different projects, to identify the benefits expected from the availability of International Standards, and to ensure adequate resources for projects throughout their development.

1.2 International standardization and the role of ISO

The foremost aim of international standardization is to facilitate the exchange of goods and services through the elimination of technical barriers to trade.

Three bodies are responsible for the planning, development and adoption of International Standards: ISO (International Organization for Standardization) is responsible for all sectors excluding Electrotechnical, which is the responsibility of IEC (International Electrotechnical Committee), and most of the Telecommunications Technologies, which are largely the responsibility of ITU (International Telecommunication Union).

ISO is a legal association, the members of which are the National Standards Bodies (NSBs) of some 140 countries (organizations representing social and economic interests at the international level), supported by a Central Secretariat based in Geneva, Switzerland.

The principal deliverable of ISO is the International Standard.

An International Standard embodies the essential principles of global openness and transparency, consensus and technical coherence. These are safeguarded through its development in an ISO Technical Committee (ISO/TC), representative of all interested parties, supported by a public comment phase (the ISO Technical Enquiry). ISO and its Technical Committees are also able to offer the ISO Technical Specification (ISO/TS), the ISO Public Available Specification (ISO/PAS) and the ISO Technical Report (ISO/TR) as solutions to market needs. These ISO products represent lower levels of consensus and have therefore not the same status as an International Standard.

ISO offers also the International Workshop Agreement (IWA) as a deliverable which aims to bridge the gap between the activities of consortia and the formal process of standardization represented by ISO and its national members. An important distinction is that the IWA is developed by ISO workshops and fora, comprising only participants with direct interest, and so it is not accorded the status of an International Standard.

2 BUSINESS ENVIRONMENT OF THE ISO/TC

2.1 Description of the Business Environment

The following political, economic, technical, regulatory, legal and social dynamics describe the business environment of the industry sector, products, materials, disciplines or practices related to the scope of this ISO/TC, and they may significantly influence how the relevant standards development processes are conducted and the content of the resulting standards:

Innovations in biomimetics such as biomimetic materials with various characteristics and performances and biomimetic processes are becoming of increasing interest in many fields of practical applications. In contrast to human-made materials, natural materials such as wood, bone and shells are composed of only a limited number of basic components. They gain their diversity in mechanical properties by hierarchical structuring which allows them to fulfill a variety of functions e.g. self-healing, resilience, mechanical stability, high toughness. In addition, biogenic materials and structures are synthesized and processed at ambient conditions, making them low-energentic solutions that outperform the majority of established technologies.
As a result of quickly advancing physical characterization techniques, knowledge about hierarchical structures has increased significantly in recent years and form-function relationships are being unveiled. But combining the knowledge about natural materials with modern techniques of simulation and fabrication is still the exception, also due to the lack of communication between natural scientists as well as engineers of various fields.

Aiming at a common language for scientists and engineers working in the field of biomimetics, the first agreed goal for standardization is work on definitions, terminology and differentiation between biomimetic and conventional methods and products.

State of the art:

Biomimetics combine the disciplines of biology and technology or other fields of innovation with the goal of solving practical problems through the abstraction, transfer, and application of knowledge gained from biological systems by interdisciplinary cooperation. Biomimetics is not limited to any specific research area. Developments inspired by nature can be found in all areas of life and industrial production starting with clothing (e.g., Velcro® or not wettable textiles) to automotive applications (e.g., nature inspired ergonomic seats, biomimetic wheel rim or optimized load-bearing components) as far as applications in medical technology (e.g., orthopedic implants, prostheses or wound pads).
One of the most important drivers in biomimetic innovation is the approach in generating new unexpected processes and products. These innovations have the potential to be sustainable. Due to the strong connection to biodiversity (need of biological systems and use of natural processes) the potential is enormous. The innovation process in biomimetics can continue beyond the singular abstraction and application of a natural principle. For example the invention of the Lotus Effect® created at least 200 side innovations. The flectofin® facade shades built after the principle of a bending mechanism in the Strelizia flower have been developed further using conventional techniques. Hence, biomimetics have the potential for a large variety of innovative products, making biomimetics an economically very efficient approach.

Dynamics:

Economic: Biomimetics has an impact on nearly all industry branches and has intersections with many research areas (e.g., nanotechnology, material sciences, surface performance, robotics, automation, sensor technology, medical engineering etc.). In various industrial processes and products biomimetics is increasingly accepted and applied. Since the year 2000 a rapid boost of products, patents, publications and events occurred.

Technical: Biomimetics is not only a creativity technique to create new ideas for production but a method for new innovation processes useful in almost all research areas and industries. Due to the immanent interdisciplinary work between natural scientists, engineers and technicians biomimetics can also be understood as a new general approach for team-building and cooperation that is necessary in most innovative product development.

Regulatory: The biomimetic origin of applications in final products is often not visible and manufacturer do not promote the use of biomimetic components or products. For example, almost all car maufactures integrate components that have been optimized with biomimetic methods. On the other hand the term “bionic” or “biomimetic” is used for promotion of products where no biomimetic approach can be found. Standards in biomimetics will give legal certainty and considerations for quality assurance in deciding whether there is a biomimetic product or not. Furthermore inspiration by nature has a stong reference to the EU’s biodiversity policy and strategy. It is obvious that the source for inspiration needs to be protected and conserved.

Societal: Biomimetics has per se a positive connotation. It combines nature with technology and therefore can be used as a role model for the so called MINT subjects (mathematics, information technology, natural sciences and engineering). Media interest is high and is a mixture of the novel science and potential benefits with concerns for environmental issues. Biomimetics has an immanent close link to nature and biodiversity. Understanding natural processes supports the public willingness to conserve nature and biodiversity.

International: Innovation and commercialization through Biomimetics is a global challenge. International collaboration is growing with the knowledge that no single country can fund the research and development necessary for the effective adoption of biomimetic processes and products. International standards for biomimetics are required to prevent technical barriers and lay the foundations for an efficient interdisciplinary cooperation in science and engineering and with all connected industry branches.

Relevant standards:

In terms of practical application, it is important that the description, specification and standardization of biomimetic approaches are used to establish a proposal for "best practice". In this sense national technical rules such as German VDI Guidelines on biomimetics can be used as input for international standardization. These Guidelines published bilingually in 2010 to 2012 give a good overview over the recent developments in biomimetics. They can build a basis for considerations on an international level.

Table 1: Examples of national technical rules (bilingual VDI-Guidelines)

VDI 6220	Biomimetics - Conception and strategy - Differences between bionic and conventional methods/products (draft: 2011-06)
VDI 6221	Biomimetics - Functional bionic surfaces (draft: 2011-07)
VDI 6222	Biomimetics - Bionic Robots (draft: 2011-11)
VDI 6223	Biomimetics - Biomimetic materials, structures and components (draft: 2011-8)
VDI 6224 Part 1	Biomimetic optimization - Application of evolutionary algorithms (2012-06)
VDI 6224 Part 2	Biomimetic optimization - Application of biological growth laws for the structure-mechanical optimization of technical components (2012-08)
VDI 6225	Biomimetics - Biomimetic information processing (draft: 2010-11)
VDI 6226	Biomimetics in architecture (in preparation)
VDI 3550 Part 3	Computational intelligence - Evolutionary algorithms - Terms and definitions (2003-2)

To date there are no other approaches known in standardization in biomimetics.

Stakeholder and initiatives:

The worldwide interest in biomimetic processes and products is growing. The interested parties (the stakeholders) in biomimetics as well as in standards on biomimetics to be elaborated by ISO/TC 266 are, i.a.:

- Various industry sectors (e.g. automotive, energy, aerospace, civil engineering, architecture, design)
- Various manufacturers (e.g. of building products, transportation systems)
- Government and ministeries (e.g. of trade and industry, transport, energy, environment, research)
- Universities, research centers, private/industrial/public development departments
- NGOs (e.g. national and international associations of trade and industry, transport, energy, environment, research)
- Consumers' associations

These stakeholders are often united in national or international networks. Therefore, in various countries scientific and enterprise networks in biomimetics have been established or will be established within the next year:

- Austria: bionic um II austria
- Belgium: Biomimicry Europa AISBL
- France:
  - Réseau Bionique Français
  - Centre européen de Biomimétisme à Senlis
  - Fonds de dotation Biomimethic
  - Mission biomimétisme du Centre Francilien de l'innovation
  - Comité Français de Biomimicry Europa
  - Institut Inspire
- Germany: BIOKON e. V.
  - Fachbereich Bionik im VDI
  - Kompetenznetz Biomimetik Baden-Württemberg
  - Bionik-Innovations-Centrum
  - Bionik-Netzwerk, Hessen
  - Internationales Bionik-Zentrum
  - GTBB
  - Cluster Bayonik
  - Bionicum, Netzwerk in Bayern
  - NICOL-Stiftung
- Israel: Israeli Biomimicry Organization
- Japan:
  - Engineering Neo-Biomimetics
  - Ask Nature Japan
  - Nature Technology Japan
  - Biomimetic Research Group, The Society of Polymer Science, Japan
  - Society of aero aqua bio-mechanism
  - Bioengineering at the Japanese Society of Mechanical Engineers
- Korea: Nature-Inspired Technology Committee
- South Africa: biomimicry sa
- Spain:
  - Convergent Science Network of biomimetic and biohybrid systems
  - Biomimicry Iberia
- The Netherlands: BiomimicryNL
- United Kingdom: Bionis – The Biomimetics Network for Industrial Sustainability
- USA: biomimicry 3.8
- International: BIOKON international

2.2 Quantitative Indicators of the Business Environment

The following list of quantitative indicators describes the business environment in order to provide adequate information to support actions of the ISO/TC 266. This list is not exhaustive:

Examples for application in industrial sectors

- Automotive (e.g., lightweight construction, sensoric, ergonomic design)

- Textile (e.g., Lotus-Effect®, light interferences)

- Automation technology (e.g., lightweight material, robotics, sensors)

- Building and construction (e.g., Lotus-Effect®-paints, insulation systems, lightweight construction, facade shades, design, self-healing materials)

- Aviation and aerospace industrie (e.g., friction reduced surfaces, lightweight construction, self-healing materials)

- Medical engineering (e.g., robotic, adhesion, Fin Ray®, wound pads, prothetics)

Products and materials

Starting in 1948 by developing Velcro® biomimetic developments and biomimetic products are established in many different sectors during the last decades.

Materials

Self-sharpening cutting tools based on rattle teeth improve the applicability of tool kits and instruments with regard to durability, stability and permancy.

Concrete is the one of the most popular construction materials. However, it is quite vulnerable to cracking because of its inherent heterogeneity, low tensile strength and the non-ideal service environment. Although reinforced concrete is designed to crack (with limited crack widths) and the cracks do not pose structural problems, these cracks provide an easy path for water and other aggressive substances to penetrate inside the concrete matrix and may impair the long term durability. Therefore, the self-healing properties of biological materials are mimicked to obtain autonomous healing of cracks. Healing agents are incorporated into the concrete matrix during casting. When cracks appear, healing agents will be released from within the concrete and flow into cracks to seal the cracks from the inside. Also other materials such as polymers, composites, coatings, ceramics, etc. can be designed to be self-healing.

Lightweight construction and other structures can benefit from the so-called "technical blade of grass", a biomimetic fibre-based composite material inspired by winter horsetail (*Equisetum hyemale*) and giant reed (*Arundo donax*). It is characterized by a high level of bending stiffness, an extremely high dynamic load capacity and damping behavior and can therefore be used for many applications, including aerospace technology, vehicle construction, building and civil engineering, machinery and equipment construction, medical technology (prosthetics) and sports equipment, etc.

The Fin Ray® effect based on fish fins is used e.g. for shape adaptive grippers and ergonomic seat backs.

Insulation materials based on the polar bear fur transport sunlight energy through hollow fibres to a black basecoat, which is heated up. Heat loss is prevented through the isolating property of the air trapped between the fibres.

Surfaces

There are over 200 patents dealing with the Lotus-Effect® and numerous practical applications include self-cleaning exterior paints, renders, and roof tiles.

Surface structures with reduced frictional resistance in connection with self-cleaning surface structures can be used e.g. for the hulls of ships and aircrafts in order to reduce fuel consumption and cleaning agents. In plastic injection moulding processes this effect is used for moulds with self-cleaning surfaces.

Unlike the skin of whales and manatees, shark skin doesn't pick up algae or barnacles. This seems to be due to little scales called "dermal denticles." Sharklet is an engineered surface that, through pattern alone, inhibits bacterial growth. The company, Sharklet Technologies, Inc., sells adhesive-backed films for covering surfaces and manufactures the pattern into medical devices like urinary catheters.

Adhesive materials based on the principle of reversible insect or gecko adhesion to plain surfaces are used for reverse conjunctions.

Optical effects and light interferences due to nano- and micro structure promote new design, fashion and marketing products

Optimization

Optimization software: Computer simulations such as the CAO (computer aided optimization) and SKO (soft kill option) methods are used for lightweight constructions resulting in considerable material savings, reduced fuel consumption as well as unconventional design.

Optimized tires and wheel rims show an important impact for road safety as well as considerable material savings.

Optimized propeller design based on vortexes created by bird's wing reduces noise and fuel consumption.

In order to reduce noise emissions of high speed trains, engineers abstracted the bills of kingfishers, which can dive into water with scarcely a splash. Kingfishers wedge themselves into water with a streamlined beak that gradually increases in diameter from tip to head, letting water flow past. By modeling bullet train noses on kingfisher beaks, West Japan Railway Company engineers created the 500 series of the Shinkansen, which entered service in 1997. The trains are quieter, 10 percent faster and use 15 percent less electricity.

Robotic

Applications for biomimetic robots can be found, e.g. in safe man-machinery interaction. The natural model in this case is the elephant's trunk. Robots using biomimetic mussles can be introduced in working surroundings not tolerable or safe for humans.

Sensoric

Active tactile sensors abstracted from insects enable contactless distance measurement and safety handling e.g. in sensitive application fields.

Biological sensors are characterized by exactness, velocity and selectivity. The transfer to technical applications is just at the beginning and show large potential for the future. They are already used e.g. for electronic nose or underwater acoustic modems using self-adaptive algorithms.

Architecture

As an example of building technology façade shade systems based on Strelizia flowers show large potential for the construction of completely new building designs.

Another example related to structural engineering is the Eastgate Shopping Center and office block in Harare, Zimbabwe, for which the structure of termite mounds was studied. The inside of a termite mound stays at near-constant temperature and humidity, no matter the conditions outside. To do this, termites open and close a series of heating and cooling vents throughout the day. Today, Eastgate uses 10 % of the energy required by similar conventional buildings, allowing also the rental rates to be lower.

Other application ranges

Other methods of optimization, such as evolutionary algorithms, can also be dealt with. Other fields of application such as agriculture, chemistry, energy, management, industrial ecology, social sciences are partly established or are under development.

In summary, this multitude and diversity of biomimetic products and their various application possibilities show the big potential and the large influence of recent and future biomimetic developments.

Patents

Generally, the numbers of patents filed per year was steadily rising over the past years in most countries. The following figure 1 shows an example chart for this development from the Republic of Korea.

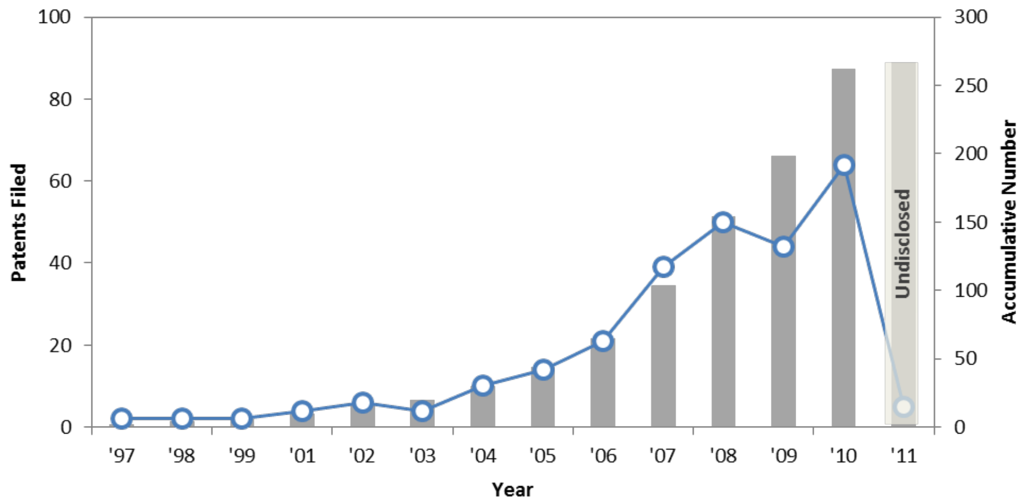


Fig. 1: Increase of patents filed per year in the Republic of Korea

- Belgium:
  1 patent on 'healing', 34 patents on Velcro are registered
- Germany:
  Patents are increasing considerably by less than 5 per year in the 1980s to more than 170 in 2009.
- Japan:
  It shows moderate upward tendency for recent years.
- Korea, Republic of:
  Patents are increasing considerably by less than 5 per year in the 1990s to more than 60 per year in 2010.
- United States of America:
  In 2009 more than 900 patents containing the word "biomimicry" were submitted to the U.S. Patent and Trademark Office (USPTO) data base (taken from: Global Biomimicry efforts, An Economic Game Changer by San Diego Zoological Society).

Literature

Similar as the situation for patents, the list of literature on biomimetics is constantly growing with increasing publications per year. To give only one example of the numbers of publications on behalf of one specific topic the following figure 2 is given. It shows contributions to the Second International Conference on Self-Healing Materials (2009), where a rough estimate of the amount of people, collaborating on a 'Self-Healing Program', has been made. Distinctions have been made between the different material classes and the different countries.

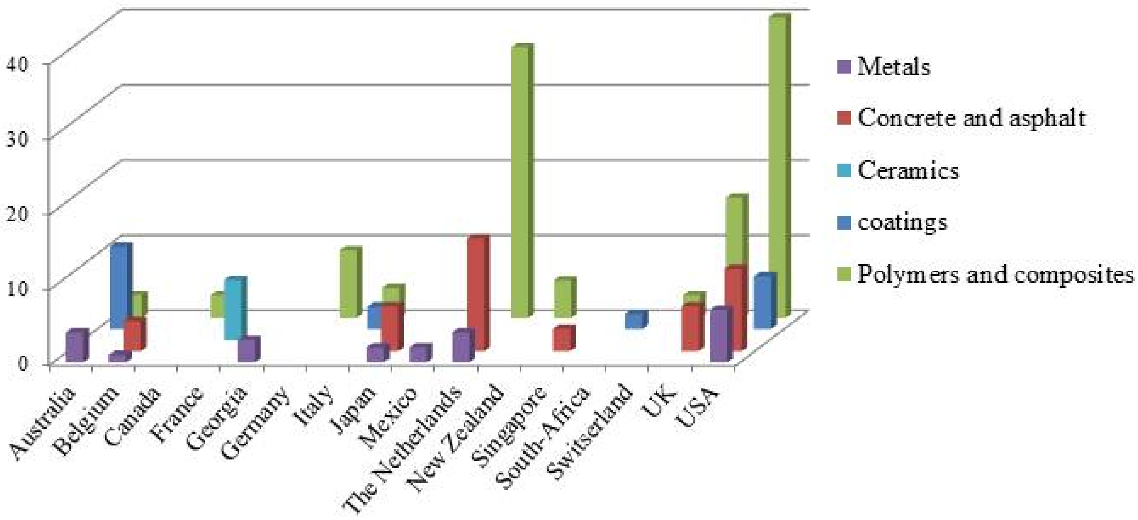


Fig. 2: Contributions to the Second Intern. Conf. on Self-Healing Materials (Chicago, 2009)

Due to the vast amount of publications only few significant ones are compiled in the following list.

- Belgium:
  Search on Biomimicry/biomimetic(s) within the Flemish universities showed following number of articles published: Ghent University 30-40; Katholieke Universiteit Leuven 30-50; Vrije Universiteit Brussel 30-40; Universiteit Hasselt 7. Total: 100-130; a search on Self-healing showed: Ghent University 40-60; Katholieke Universiteit Leuven 20-30; Vrije Universiteit Brussel 30-40; Universiteit Hasselt 0. Total: 90-130
- France:
  - « Études & documents : Étude sur la contribution du biomimétisme à la transition vers une économie verte en France une économie verte en France : état des lieux, potentiel, leviers » COMMISSARIAT GÉNÉRAL AU DÉVELOPPEMENT DURABLE n° 72 Octobre 2012
  - « Biomimétisme et matériaux », Observatoire français des techniques avancées, CNRS le journal - N°268 - septembre-octobre 2012 - La nature pour modèle
  - « Quand la Nature Inspire la Science » Mat Fournier – 2011
  - « La vie, quelle entreprise », R. Barbault et J. Weber – 2010
  - « Les systèmes complexes- mathématiques et biologie », Hervé Zwirn – 2006
  - « Géométries du Vivant » Alain Prochiantz -2012
  - « Chimie des processus biologiques » Marc Fontecave -2009
  - « Chimie des matériaux hybrides » Clément Sanchez -2012
  - « Vive la co-révolution » A.S. Novel et S. Riot -2012
  - « Industry of Nature » MateriO -2012
- Germany:
  Publications dealing with biomimetic topics are increasing considerably by less than 10 per year in the early 1970s to more than 1000 in 2009.
- Japan:
  Overall number of scientific papers on biomimetics is increasing slowly but steadily

from 2008 to 2012 (57 in 2008, 57 in 2009, 65 in 2010, 71 in 2011, 42 in 2012. Last updated on Feburuary 19, 2013.)
  - PEN yearbook, Kyodo Bunkasha, 2012
  - The new trends in next generation biomimetic materials engineering: learning from biodiversity, CMC Publishing, 2011
- Korea, Republic of:
  1. 'From clean manufacturing technology to green technology', vol. 3 (ISBN: 978-89-8245-005-1-93530), 2. 'Nature is great teacher.' (ISBN: 9788934957898)

Study courses

This list is not exhaustive and includes the participating members as well as known networks. At least information from these countries is appreciated.

- Belgium:
  The following number of courses in Flanders was found to have a link to:

  (a) Biomimetics:
  - Applied biodiversity science: Ghent University
  - Advanced polymer chemistry: Ghent University
  - Computational techniques: Ghent University
  - Technology and environment: Ghent University
  - Biosystems: Ghent University
  - Nanoporous materials: Ghent University
  - Design methodologies: KULeuven
  - Nanostructured bio-macromolecules: KULeuven
  - Biomachines and biomimetics: KULeuven
  - Practical college on new materials: Vrije Universiteit Brussel
  - Case studies on composite technologies in the air and space industry: Vrije Universiteit Brussel

  (b) Self-healing/self-repair:
  - Applied biodiversity science: Ghent University
  - Advanced polymer chemistry: Ghent University
- France:
  - Institut de Chimie des Substances Naturelles, Orsay
  - Chimie des processus biologiques, Collège de France
  - Synthèse et Auto-assemblage Moléculaires et Supramoléculaires, Institut Charles-Sadron
  - Laboratoire de chimie biomimétique des métaux de transition, Institut de Chimie, Université de Strasbourg
  - Laboratoire de photocatalyse et biodydrogène - Institut de biologie et de technologie de Saclay, DSV, CEA
  - Chimie des processus biologiques, Collège de France
  - Photocatalyse - Laboratoire des Matériaux, Surfaces et procédés pour la Catalyse (LmSPC) CNRS
  - Matériaux hybrides et nanomatériaux - Laboratoire de chimie de la matière condensée CNRS, collège de France, UPMC
  - Matériaux et biologie - Laboratoire de chimie de la matière condensée CNRS, collège de France, UPMC
  - Surfaces superhydrophobes - LadHyx- Ecole Polytechnique
  - Nanotechnologies bio-inspirées - Génopôle Evry
  - Matériaux naturels et biomimétiques - Réseau BRESMAT (Bretagne RESeau MATériaux)
  - Chimie biomimétique des matériaux de transition - Faculté de chimie, Univ de Strasbourg

  - Neurocybernétique - Equipes traitement de l'information et système -ENSEA - Université de Cergy Pontoise
  - Mathématiques du Vivant - Institut de mathématiques de Bordeaux
- Germany:
  The possibility for studying "biomimetics" is increasing considerably. More than ten universities offer thematic tracks in biomimetics, three universities offer master and bachelor degree courses in biomimetics. Some of these comprise as follows:
  - RWTH Aachen: Ringvorlesung/Seminar Bionik (Basics and methods of biology and technology, problem solving, technical realization)
  - RWTH Aachen: Neurobionik
  - TU Berlin: Bionik (Basics, biosensors, bioinformatics)
  - TU Berlin: Evolutionary technology
  - Westfälische Hochschule Gelsenkirchen, Bocholt, Recklinghausen: Bionik (Sensors and lightweight design)
  - Universität Bonn: Electronics for Bioniks
  - Universität Bonn: Machine Learning in Python
  - Universität Bonn: Lecture Bionics
  - Hochschule Bremen: Bachelor of Science in study course “Bionik”
  - Universität Freiburg: Funktionelle Morphologie und Biomechanik der Pflanzen
  - Universität Freiburg: Moderne Methoden der Pflanzennutzung, Biotechnologie, Biomimetik
  - Hochschule Hamm-Lippstadt: Bachelor of Science in study course „Materialdesign - Bionik und Photonik“
  - TU Ilmenau: Study course „Biomechatronik“
  - Hochschule Karlsruhe: Bionik
  - TU München: Bionik
  - TU München: Bionische Lösungsprinzipien für Gebäudehüllen
  - TU München: Biologisch inspirierte Systeme
  - Hochschule Rhein-Waal: Master of Science study course „Bionics/Biomimetics“
  - Karlsruhe Institute of Technology: Biomechanik
  - Karlsruhe Institute of Technology: FEM Workshop
  - VDI: Leichtbau von Bauteilen mit bionischen Methoden”
- Japan:
  A handful of universities offer courses in biomimetics as independent track. Many universities provide courses in biomimetics as a part of engineering courses.
  - Graduate School and Faculty of Engineering, Chiba University
  - School of Life Scineces, Tokyo University of Pharmacy and Lifesciences
  - College of Engineering, Ibaraki University
  - Faculty of Textile Science and Technology, Shinshu University
  - Department of Mechanical Science and Bioengineering, Graduate School of Engineering Science, Osaka University
- Korea, Republic of:
  1. Organization: Department of Advanced Technology Fusion, Konkuk University
     Course title: Biomimetics(5280)
  2. Organization: Robotics Engineering Department, DGIST,
     Course title: Biomimetics Engineering (RT652)
  3. Organization: Department of Mechatronics Engineering, Chungnam National University
     Course title: Biomimetics/Nature-inspired Engineering
  4. Organization: Department of Nano-Mechatronics, University of Science and Technology
     Course title: Biomimetics/Nature-inspired engineering
  5. Organization: Department of Mechanical Engineering, POSTECH
     Course title: Scaling Laws and Biomimetics

6. Organization: Department of Bio and Brain Engineering, KAIST
   Course title: Topics in Biomimetics

Economy

Up to now revenue data is difficult to assess for specific countries or industries. However, there is a study available from the San Diego Zoological Society (Global Biomimicry efforts, An Economic Game Changer) which states that over the next 15 years, biomimicry-based goods and services could account for approximately $300 billion of U.S. gross domestic product (GDP) by 2025. To put this figure in perspective, in 2010 U.S. companies have spent an estimated $282 billion on computer software. While initially small relative to a total U.S. economy that is estimated to generate approximately $21 trillion of goods and services in 2025, biomimicry will still have a highly significant impact that can be expected to continue to grow rapidly as knowledge and the field expand.

The same study claims that biomimicry could also spread rapidly on a global scale. Assuming a smaller GDP share of 1.0% than the 1.4% calculated for the U.S. (with lesser shares among less technically advanced nations), biomimicry could affect about $1.0 trillion of the world's total output by 2025.

3 BENEFITS EXPECTED FROM THE WORK OF THE ISO/TC

Sustainability:
Biomimetic product design is often employed to benefit from product improvement. This may span increase of functionality, resource efficiency or product life as well as decrease of energy consumption, emissions or cost among a number of other reasons.

Academia:
Biomimetics is based on interdisciplinary cooperation and networking. The mutual scientific exchange will promote research and innovation. Standards in biomimetics give academia a common language and terminology for education and collaboration on research. This would allow biomimetics to be incorporated as a standard design approach.

Business:
Biomimetics can act as an innovation engine that pushes the economy and has impact on businesses. Standardization will give businesses tools for developing biomimetic strategies for new products, resulting in an expanded product development portfolio and new products for the market. Standards as a language of technology are understood and accepted in countless branches of industry. The procedures described can be used as objective benchmark and their reproducibility is demonstrated. Outlining results in standards strengthens confidence in biomimetics, therefore, making it easier to close the gap between research and commercialization efforts. In industrial environments quality assurance of products and processes is of high significance to which standards in biomimetics will greatly contribute by providing mutual acceptance. Standards also play an important role for the efficient fulfillment of due diligence requirements needed in business relationships.

The development of ISO-standards in biomimetics makes it easier to establish references between basic design standards in certain fields and suitable biomimetic processes. This allows industries to integrate biomimetic methods into their product and process design routes without having to fear non-acceptance by customers. Synergies can be expected in product development – even in international teams from different stakeholders such as industry and/or research institutions – when unified standards are applied throughout the complete product life cycle from first drafts to choice of materials and resources to manufacturing to recycling and waste management.

Customers/Products:
Biomimetic products can be potentially more sustainable and more environmentally compatible than conventional ones. This, however, depends strongly on effective implementation of reduced resource consumption and emissions, e.g. by means of manifold types of optimization or lightweight design. In order to analyze aspects relevant to sustainability individual case studies of each biomimetic product are necessary. Furthermore, biomimetics can help create new products or even new technology fields from bottom up. Standards will contribute to the overall acceptance of biomimetic new or optimized products.

Legal aspects:
Means of standardization will help increase the acceptance of biomimetic products and approaches such that a wider recognition of the field not only among experts is expected. Hence, customers can be sure that products advertised as biomimetic are indeed such. In legal proceedings, it will be possible to determine whether a product or parts thereof can be deemed "biomimetic" and when not. Other ISO-TCs can benefit from standards in biomimetics by cross-referencing rules and recommendations for use in other standards and for clear separation of biomimetics from other topics.

Summary:
The identification of suitable underlying principles in biology and implementing them in biomimetic technical applications is a major contribution towards developing functional adaptive, resource- and energy-efficient applications including materials, structures and components that are safe for humans and the environment. Standardization in this area plays an important role towards disseminating biomimetics for sustainable technical development. The ISO TC members expect the installation of standards in biomimetics to push the topic and prepare for the next technological leap which should lead to wide acceptance of the methods discussed in the standards.

4 REPRESENTATION AND PARTICIPATION IN THE ISO/TC

4.1 Countries/ISO members bodies that are P and O members of the ISO committee

4.2 Analysis of the participation

5 OBJECTIVES OF THE ISO/TC AND STRATEGIES FOR THEIR ACHIEVEMENT

5.1 Defined objectives of the ISO/TC

Biomimetics include various scientific/technological disciplines. Therefore it is necessary to connect these fields with an independent Technical Committee in ISO. It is reasonable to start international standardization at an early stage – when the industrial demand expands and worldwide research and development increases. It can be assumed that global interdisciplinary cooperation will be fostered and smoothed by having international standards at an early stage of biomimetic developments.

The prime objective of the ISO/TC is the development of an International Standard regarding teminology and the differentiation between biomimetics and conventional products and processes. Such a general standard would thus contribute considerably to the quality assurance of biomimetic methods, materials, processes and products.

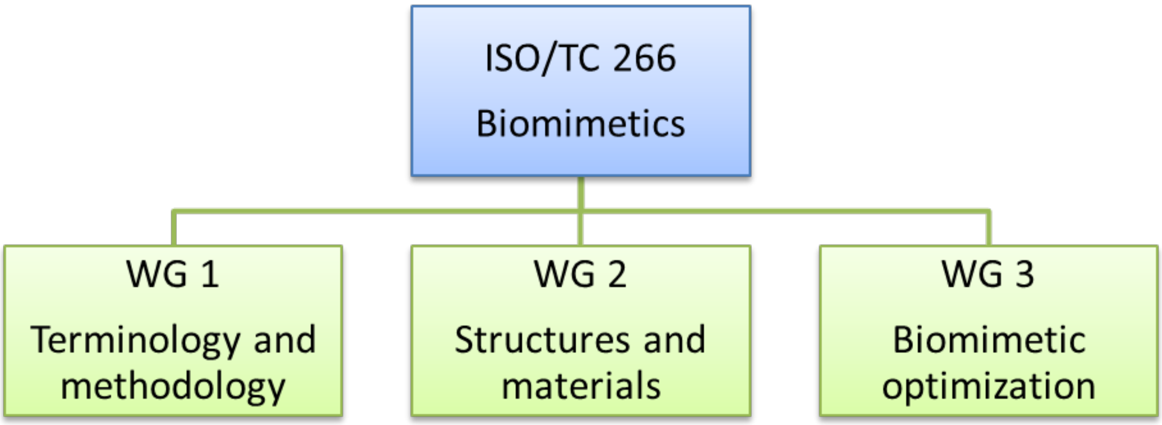
Parallel to the work on terminology the ISO/TC will develop further International Standards. The most promising approaches for the use of developers, designers, engineers, technical and natural scientists are standards concerning advanced materials and biomimetic optimization:
An International Standard regarding biomimetic methods, structures and materials will be developed describing the transfer of biological principles into technical applications.
International Standards including biomimetic optimization, evolutionary algorithms and biomimetic information processing will be developed concurrently.

5.2 Identified strategies to achieve the ISO/TC's defined objectives

The Association of German Engineers (VDI) has developed a number of different VDI Guidelines for various fields in biomimetics (overview in section 2.1). In these Guidelines a definition of the differentiation between biomimetics and conventional processes (and its relation) has been drawn up and the general concept and strategy of biomimetics, terminology and further definitions are specified. Additionally, the Guideline regarding biomimetic materials, structures and components and the Guidelines regarding biomimetic optimization show high relevance for practical appilcations. These national Guidelines can therefore be used as a basis for the development of International Standards.

To ensure efficient work of the ISO/TC the following three Working Groups will be set up.

WG 1: Terminology and methodology
WG 2: Structures and materials
WG 3: Biomimetic optimization



The basic terminology and the definition of biomimetics shall be completed first. However by using the national Technical rules, e.g. VDI-Guidelines the projects within the Working Groups can be processed in parallel. The members of the ISO/TC 266 have to constantly compare the results to avoid unnecessary duplication of work and contradictory developments and to ensure the development of a consistent terminology.

Liaisons should be established with relevant international initiatives and stakeholders. International initiatives provide a forum for information, discussion and collaboration for its members and the scientific community, acting together in regional and international projects, organizations and institutions.

As biomimetics can be used in many fields of practical applications, cooperation should be established with some already established ISO/TCs. Regarding the described work programme, the following ISO/TCs should be considered.

ISO/JTC 1	"Information technology"
ISO/TC 35	"Paints and varnishes"
ISO/TC 37	"Terminology and other language and content resources"
ISO/TC 39	"Machine tools"
ISO/TC 98	"Bases for design of structures"
ISO/TC 107	"Metallic and other inorganic coatings"
ISO/TC 184	"Industrial automation systems and integration"
ISO/TC 207	"Environmental management"
ISO/TC 229	"Nanotechnologies"
CEN/TC104/SC8	"Protection and repair of concrete structures"
CEN/TC 350	"Sustainability of construction works"
CEN/TC 389	"Innovation"
CEN TC 411	"Biobased products"
ISO/TC 168	"Prosthetics and orthotics"

6 FACTORS AFFECTING DELIVERY AND IMPLEMENTATION OF THE ISO/TC WORK PROGRAMME

Guidelines of the Association of German Engineers regarding biomimetics are available in English and can be used as a starting point for the development of International Standards. This will significantly shorten the time to develop International Standards.

One key-factor for the successful development and implementation of International Standards is the involvement of leading experts from the academic world and especially from the industrial sector. In addition further member bodies (countries) should be included into the work. At this time there are sufficiently enough experts available to the ISO/TC group. Moreover, none of the key positions in the ISO/TC are currently vacant provided that the next general assembly accepts one of the two candidates for convenorship of WG2.

From the currently planned activities it can be stated that no research and/or development is necessary before results of the three working groups as defined above are finalized. This reduces the risk of making these results unobtainable.

Also, no legal or regulatory issues are known todate which may influence the outcome of the activities of this ISO/TC.

In order to reflect the society’s needs properly the standardization process has to be transparent. Japan started to publish newsletter from Japanese Industrial Standards Committee (JISC) and deliver to all of the stakeholders for this purpose. This should help reduce the risk of none-acceptance of the results of the ISO/TC.

7 STRUCTURE, CURRENT PROJECTS AND PUBLICATIONS OF THE ISO/TC

This section gives an overview of the ISO/TC’s structure, scopes of the ISO/TCs and any existing subcommittees and information on existing and planned standardization projects, publication of the ISO/TC and its subcommittees.

7.1 Structure of the ISO committee

7.2 Current projects of the ISO technical committee and its subcommittees

7.3 Publications of the ISO technical committee and its subcommittees

Reference information

Glossary of terms and abbreviations used in ISO/TC Business Plans

General information on the principles of ISO's technical work