Engineering Neo-Biomimetics VI

and Satellite Workshop at Lake Biwa

October 22th (Thu) - 23rd (Fri), 2015

October 22th (Thu)

島津製作所三条工場内 新本館1F セミナーホール
京都市中京区西ノ京桑原町1

Sanjo Works, Shimadzu Corporation, seminar hall
1 Nishinokyo Kuwabara-cho, Nakagyo-ku, Kyoto 604-8511, Japan

October 23rd (Fri)

滋賀県立琵琶湖博物館
滋賀県草津市下物町1091番地

Lake Biwa Museum
1091 Oroshimo, Kusatsu, Shiga 525-0001, Japan

ラ コリーナ近江八幡
滋賀県近江八幡市北之庄町615-1

La Collina Omihachiman
615-1 Kitanosho-cho, Omihachiman, Shiga 523-0806, Japan

Organized by
Innovative Materials Engineering Based on Biological Diversity, Ministry of Education, Culture, Sports, Science and Technology (MEXT, Japan)
共催：文部科学省　科学技術研究費補助金（新学術領域）「生物規範工学」

Co-organized by
Ask Nature Japan
協賛：アスクネイチャー・ジャパン

PROGRAM

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October 22nd (Thu)

09:30-09:35 Opening Remarks
Prof. Masatsugu Shimomura (Chitose Institute of Science and Technology, Japan)

15:35-15:5Ω Coffee Break

15:50-16:15

16:15-16:40

16:40-17:05

17:05-17:30

17:30-18:30 Poster Session

October 23rd (Fri)

Satellite Workshop of "Engineering Neo Biomimetics VI" at Lake Biwa Museum and "La Collina"

13:30-15:30
Lake Biwa Museum
Science tour of the Lake Biwa Museum and discussion on "role of natural history museum for biomimetics"

15:30- leave to "La Collina" by bus

16:30-18:00
"La Collina"
A round table discussion on "international collaboration of biomimetics for education, industrial development, and sustainability"

18:00-20:00
Banquet at "La Collina"

Poster Session

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October 22th (Thu) 17:30-18:30

Dr. Heike Beismann, Prof.

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Biology and Biomimetics

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Education & Academic Background

1993 Diploma in Biology, Albert-Ludwigs-University Freiburg, Germany
1994 Research assistant, Albert-Ludwigs-University Freiburg, Germany
1998 Dissertation, Albert-Ludwigs-University Freiburg, Germany
1998-2000 Research assistant, Botanic Intitute, University of Basel, Switzerland
2000-2004 Research assistant, Chair of Vegetation Ecology, Department for Ecology and Ecosystem Management, Weihenstephan, Technische Universität München, Freising.
2004-2009 Scientific employee and leader of Technical Division III, Commission on Air Pollution Prevention of VDI and DIN, VDI - The Association of German Engineers, Düsseldorf, Germany
2009-2012 Secretary VDI-Society Technologies of Life Sciences, VDI – The Association of German Egineers, Düsseldorf, Germany
since 2012 Professor, Department of Mechanical Engineering, Westphalian University of Applied Sciences

Standardization Work

Participant of ISO/TC 266 Biomimetics
Convenor of Working Group1 Terminology and methodology of ISO/TC 266 Biomimetics
Published International Standards: ISO 18458: 2015 Biomimetics - Terminology, concepts and methodology, ISO 18459:2015 Biomimetics - Biomimetic structural optimization
Member of German Standards Committee NA 062-08-60 AA "Bionik”, DIN e.V.
Member of Advisory Board Biomimetics, VDI e.V.
Published VDI Guidelines for Biomimetics: VDI 6220 – 6226

Recent Publications

- Züghart W, Beismann H, Schröder W (2013): Tools for a scientifically rigorous and efficient monitoring of genetically modified organisms (GMOs) – VDI Guidelines to ensure high quality of GMO-monitoring data. BioRisk 8: 3-13.
- Beismann H., M. Finck, H. Seitz (2007): Standardisation of methods for GMO Monitoring on a European level. Journal of Consumer Protection and Food Safety 2, Supplement 1: 76-78.
- Beismann H. (2006): Measuring the effect of air pollution on the environment with standardized methods. Report of the commission on air pollution prevention of VDI and DIN. In: International Journal of Hygiene and Environmental Health 209 (2): 207–208.
- Beismann H., Franzaring J. (2006): Standardization of bioindication methods for air quality control in Germany. Environmental Bioindicators 1: 217–222.
- Finck, M.; Seitz, H.; Beismann, H. (2006): Concepts for General Surveillance: VDI Proposals Standardisation and Harmonisation in the Field of GMO-Monitoring. Journal of Consumer Protection and Food Safety 1, Supplement 1:11–14.

Standardization in the Field of Biomimetics An International Challenge

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The systematic monitoring of nature and the transfer of complex principles from biology to engineering (biomimetics) has become increasingly important over the last few years. The highly innovative potential of biomimetics makes it extremely attractive to companies.

Biomimetics relies on the interaction between biological and technical knowledge, and that is where two different worlds collide. It is obvious that the transfer of knowledge from biomimetics research to technical implementation is key to the companies who have expressed an interest in this area. Successfully transferring knowledge about structures, processes, and the properties of living systems to technical systems requires clear communication, correspondence, and transparency across the disciplines.

One way of achieving this goal is to transfer knowledge via standards and guidelines. Standards and guidelines are formulated in a technical language that makes it easier for the engineers involved in the implementation of the idea to grasp the biological aspects. Definitions and common terminology in recognized regulations are a way of establishing biomimetic procedures and manufacturing methods. As a result, standards can represent key elements of the corporate strategy that can be used to demonstrate process and product quality, meet safety standards, and comply with quality standards.

Currently the standardization process on an international scale via ISO is underway and is attempting to develop a mutual understanding of the concepts and methods of biomimetics. Collaboration from business representatives is expressly encouraged, as this is the only way that the needs of the industry can be incorporated into the standards. The first ISO standards relating to biomimetics are already published. Additional standards relating to specific topics are in the pipeline. ISO 18458:2015 “Biomimetics - Terminology, concepts and methodology” provides an overview of the various areas of application and describes how biomimetic methods differ from classic forms of research and development. This standard also helps to determine from what point a product is to be regarded as biomimetic. ISO 18459: 2015 “Biomimetics - Biomimetic structural optimization” specifies the functions and scopes of biomimetic structural optimization methods.

Alltogether, regulations are an important aid in securing the appeal of biomimetics and developing it for companies.

Dr. Naoe HOSODA, Prof.

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Education & Academic Background

- Ph.D from Stuttgart University
- Max-Plank Institute for Metal Research (Germany), (researcher)
- The University of Tokyo, Research Center for Advanced Science and Technology, (research associate)
- The University of Tokyo, Department of Precision Engineering (associate professor)
- National Institute for Materials Science (2003 – present)
- The University of Tokyo, Department of Precision Engineering (professor/ additional post)

Award

- 2000, Micro Electronics Symposium, Best Paper Award
- 1996, 8th Japan Institute of Metals International Symposium Interface Science and Materials Interconnection, Best Poster Award

Recent Publications

- R. Tsubaki, N. Hosoda, H. Kitajima, T. Takanashi, "Substrate-Borne Vibrations Induce Behavioral Responses in the Leaf-Dwelling Cerambycid, *Paraglenea fortunei*", *ZOOLOGICAL SCIENCE* Vol.**31**, (2014) 789–794.
- N.Hosoda, "The Mechanisms of Organisms as Eco-Materials Design Tools", J.Kauffman, K.-M.Lee(eds),Handbook of Sustainable Engineering, Springer, 1249-1261, 2013
- Naoe Hosoda and Stanislav N.Gorb , "Underwater locomotion in a terrestrial beetle:combination of surface de-wetting and capillary forces", *Proceedings of the Royal Society B,* 279, pp.4236-4242, 2012
- Naoe Hosoda and Stanislav N.Gorb,"Friction force reduction triggers feet grooming behaviour in beetles", Proceedings of the Royal Society B, doi:10.1098/rspb.2010.1772, Published online, 2010, [Proc.R.Soc.B (2011) 278,1748-1752]
- Dagmar Voigt, Naoe Hosoda, Jan Schuppert, Stanislav Gorb "On the laboratory rearing of green dock leaf beetles Gastrophysa viridula (Coleoptera: Chrysomelidae)", 00, 1–6, *INSECT SCIENCE*, 2010
- E.V.Gorb, N.Hosoda, C.Miksch, S.N.Gorb, "Slippery pores: anti-adhesive effect of nanoporous substrates on the beetle attachment system", *Journal of the royal society interface*, 7, 1571-1579, 2010
- P.P. Goodwyn, Y. Maezono, N.Hosoda and K.Fujisaki, "Waterproof and translucent wings at the same time: problems and solutions in butterflies", *Naturwissenschaften, Springer*, vol. 96, no. 7, pp. 781-787, 2009
- Naoe Hosoda, "Gecko's wonder world", *Expected materials for the future*, Vol.7,no.4,pp5-7 (2007)
- Gerrit Huber, Stanislav N.Gorb, Naoe Hosoda, Ralph Spolenak and Eduard Arzt, "Influence of surface roughness on gecko adhesion", *Acta Biomaterialia,*3.4,pp.607-610,2007
- N.Hosoda, T.Suga, S.Obara and K.Imagawa, "UHV-Bonding and Reversible Interconnection", *Transactions of the Japan Society for Aeronautical and Space Sciences*,49.166, pp.197-202,2007
- Naoe Hosoda and Stanislav N.Goeb, "Influence of surface energy and roughness on adhesion of the beetle Gastrophysa viridula", *Journal of Biomechanics*,391,s349,2006
- A.G.Peressadko, N.Hosoda and B.N.J.Persson, "Influence of Surface Roughness on Adhesion between Elastic Bodies", *Physical Review Letters*,95,pp.124301-1 - 124301-4,2005

Biomimetic Bonding Technology

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A design which enables easy disassembly is an important requirement for environment-friendly products, and interconnection disassembly techniques are the key technology for this purpose. In many cases, conventional joining techniques were developed with importance placed only on high joint strength, resulting in joints which are difficult to disassemble. Thus, while the reliability of the joint in use must be assured, environment-friendly next-generation joining techniques must also consider joint separation. This means that joining methods which combine the apparently-contradictory elements of resistance to separation and easy disassembly are required. Moreover, with progressive micro-scaling of parts, the development of new joining techniques which do not result in unnecessarily high strength and allow easy disassembly is also required in micro-assembly.

The natural world offers valuable suggestions for this purpose. In particular, our attention was drawn to small animals, which are similar in size to micro-machines. Single setae of the attachment device at the tip of the legs of insects such as flies and beetles are several microns in size and has evolved to attach to surfaces by adhesion. Moreover, it is an excellent mechanism for quick, precise, and reversible attachment.

We investigated the adhesive characteristics of the attachment device of the terrestrial leaf beetles *Gastrophysa viridula*. Limit of adhesive ability was found on a surface structure with a nano scale. we have discovered the remarkable ability of the beetle to walk on solid substrates under water. These beetles use air bubbles trapped between their adhesive setae to walk on flooded, inclined substrata or even under water. Inspired by this idea, we designed an artificial silicone polymer structure with underwater adhesive properties.

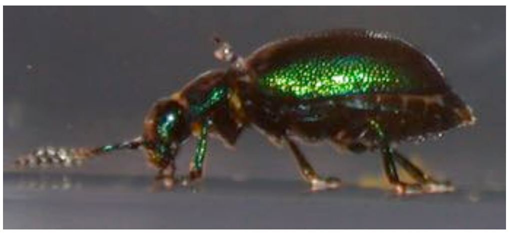

Fig.1 Beetle *Gastrophysa viridula*. Beetle walking under water.

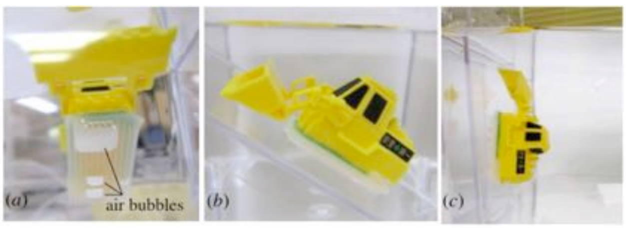

Fig.2 Plastic toy bulldozer adhering to the substrate using structured polymer with trapped air bubbles under water. (a) Air bubbles trapped between pillars of the structured polymer. (b)Substrate slope of 30°. (c).Substrate slope of 90°.

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Education & Academic Background

1988 Master of Engineering the Graduate School of Engineering, Hokkaido University
1989-1993 Research Associate, Research Institute for Electronic Science, Hokkaido University
1994-2004 Associate Professor at the Graduate School of Information Science and Technology, Hokkaido University
1995-1996 Visiting Associate Professor, Washington University, USA
2006 Professor, Graduate School of Information Science and Technology, Hokkaido University
2007- Associate member of Information and Communications Council, Ministry of Internal Affairs and Communications, Japan
2008-2010 A Board member/Chief Technical Adviser of the Information Grand Voyage Project, Ministry of Economy, Trade and Industry, Japan
2008- A member of NHK Broadcasting Technology Council, Japan Broadcasting Corporation (NHK)
2011-2013 Vice-President of ITE, Japan
2011- Member of the Science Council of Japan
2013-2014 Director, International Coordination and Publicity, IEICE
2013- Adviser to the President, Hokkaido University
Award: Info-Communications Promotion Month Commendations by Director-General of Hokkaido Bureau of Telecommunications, the Ministry of Internal Affairs and Communications in 2014, The Institute of Image Information and Television Engineers, Niwa & Takayanagi Achievement Award in 2015

Recent Publications

- Miki Haseyama: " Biomimetics Image Retrieval Platform for Enhancing Serendipity," Taxa : proceedings of the Japanese Society of Systematic Zoology, vol. 38, pp. 22-25 (2015)
- Miki Haseyama: "Biomimetics Data Retrieval Platform for Enhancing Serendipity," Joint international symposium on "Nature-inspired Technology (ISNIT) 2014" and "Engineering Neo-biomimetics V", pp. 56-57 (2014)
- Ryosuke Harakawa, Takahiro Ogawa, and Miki Haseyama: "An Efficient Extraction Method of Hierarchical Structure of Web Communities for Web Video Retrieval," ITE Transactions on Media Technology and Applications, vol. 2, no. 3, pp. 287-297 (2014)
- T. Ogawa, D. Izumi, A. Yoshizaki, M. Haseyama, "Super-resolution for simultaneous realization of resolution enhancement and motion blur removal based on adaptive prior settings", EURASIP Journal on Advances in Signal Processing 2013, vol. 2013:30, DOI: 10.1186/1687-6180-2013-30 (2013).
- T. Ogawa, M. Haseyama, "Missing texture reconstruction method based on error reduction algorithm using Fourier transform magnitude estimation scheme", IEEE Transactions on Image Processing, 22(3), 1252-1257 (2013).
- M. Haseyama, T. Ogawa, "Trial Realization of Human-Centered Multimedia Navigation for Video Retrieval" International Journal of Human-Computer Interaction, 29(2), 96-109 (2013).
- M. Haseyama, T. Ogawa, N. Yagi, "A Review of Video Retrieval Based on Image and Video Semantic Understanding" ITE Transactions on Media Technology and Applications, 1(1), 2-9 (2013).
- R. Harakawa, T. Ogawa, M. Haseyama, "An Extraction Method of Hierarchical Web Communities for Web Video Retrieval", 2013 IEEE International Conference on Image Processing (ICIP 2013), 4397-4401 (2013).
- M. Haseyama, D. Matsuura, "A Filter Coefficient Quantization Method With Genetic Algorithm, Including Simulated Annealing" IEEE Letters on Signal Processing, 13(4), 189-192 (2006).

Biomimetics Image Retrieval：Connecting Biology and Engineering

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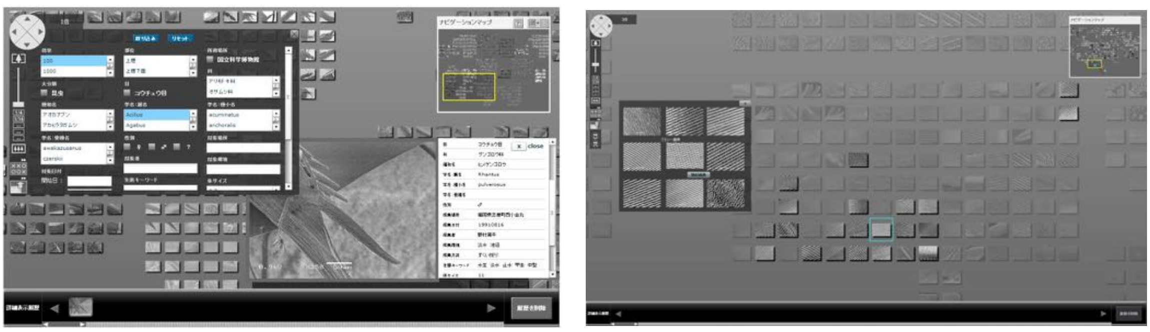
Biomimetics is a new research area that creates innovation through the collaboration of different existing research fields. Biomimetics therefore brings together expert researchers with deep knowledge of various research fields, and there is a need to facilitate the mutual exchange of their knowledge to create new research areas. However, this exchange is difficult due to several reasons, e.g., differences in technical terms between different fields. In order to overcome this problem, we began the development of a new image retrieval platform. A biological database contains a large number of images, and by taking advantage of this data, we are able to overcome limitations of text-only information retrieval. If such an image retrieval which does not depend on text data is realized, individual biological databases of various species (insects, fish, etc.) will be integrated. This will allow not only the study of the various species by researchers in different biological fields, but also access for a wide range of researchers in fields such as material science and manufacturing. In practice, our "Biomimetics Image Retrieval Platform" is implemented as shown below. The platform enables retrieval without relying on any keywords, and researchers can retrieve novel information from biological image databases by using their own image data. In the presentation, the latest version of the Biomimetics image retrieval platform is introduced, and the actual retrieval results are shown. Based on the results, we will discuss whether the synergy of different research fields is created by Biomimetics Image Retrieval Platform.



(a) Interface of the Biomimetics image retrieval Platform (b) Example of the retrieved results

Fig. 1 Biomimetics Image Retrieval Platform

Dr. Takashi OKUDA, Senior researcher

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- Website: http://www.nias.affrc.go.jp/anhydrobiosis/Sleeping%20Chironimid/index.html
- Address: 1-2, Ohwashi, Tsukuba, Ibaraki, 305-8634 Japan

Education & Academic Background

1981 Department of Agriculture, Faculty of Agriculture, Gifu University (MSc)
1984 Czechoslovak Academy of Sciences, Institute of Entomology (PhD)
1985 Lecturer at Nagoya Gakuin University
1986 Research fellow at Medical School of Mie University
1987-88 Visiting Research Fellow at International Center of Insect Physiology and Ecology (ICIPE), Kenya
1989 Post-doctoral fellow at Mitsubisi-kasei Life Sciencei Research Institute
1989-present National Institute of Agrobiological Sciences

Award: 2001 The Takeda Techno-Entrepreneurship

Recent Publications

- R. Cornette , Kanamori Y, Watanabe M, Nakahara Y, Gusev O, Mitsumasu K, Kadono-Okuda K, Shimomura M, Mita K, Kikawada T, Okuda T "Identification of anhydrobiosis-related genes from an expressed sequence tag database in the cryptobiotic midge Polypedilum vanderplanki (diptera; chironomidae)" Journal of Biological Chemistry 285 (46) : 35889-35899. (2010)
- O.Gusev, Cornette R, Kikawada T, Okuda T "Expression of heat shock protein-coding genes associated with anhydrobiosis in an African chironomid Polypedilum vanderplanki" Cell Stress & Chaperones (2010)
- O. Gusev, Nakahara Y, Vanyagina V, Malutina L, Cornette R, Sakashita T, Hamada N, Kikawada T, Kobayashi Y, Okuda T "Anhydrobiosis-associated nuclear DNA damage and repair in the sleeping chironomid: Linkage with radioresistance" PLoS ONE 5(11): e14008 (2010)
- K. Mitsumasu, Kanamori Y, Fujita M, Iwata K, Tanaka D, Kikuta S, Watanabe M, Cornette R, Okuda T, Kikawada T "Enzymatic control of anhydrobiosis-related accumulation of trehalose in the sleeping chironomid, *Polypedilum vanderplanki* "*FEBS Journal* 277(20): 4215–4228 (2010)
- Y. Kanamori, Saito A, Hagiwara-Komoda Y, Tanaka D, Mitsumasu K, Kikuta S, Watanabe M, Cornette R, Kikawada T, Okuda T "The Trehalose transporter 1 gene sequence is conserved in insects and encodes proteins with different kinetic properties involved in trehalose import into peripheral tissues" *Insect Biochemistry and Molecular Biology* 40(1): 30-37 (2010)
- Y. Nakahara, Imanishi S, Mitsumasu K, Kanamori Y, Iwata K, Watanabe M, Kikawada T, Okuda T "Cells from an anhydrobiotic chironomid survive almost complete desiccation" *Cryobiology* 60(2): 138-146 (2010)
- T.Shimizu, Kanamori Y, Furuki T, Kikawada T, Okuda T, Takahashi T, Mihara H, Sakurai M "Desiccation-induced structuralization and glass formation of Group 3 late embryogenesis abundant protein model peptides" *Biochemistry* 49(6) : 1093–1104 (2010)
- M.Sakurai, Furuki, T., Akao, K., Tanaka D., Nakahara, Y., Kikawada, T, Watanabe M. and Okuda, T. "Vitrification is essential for anhydrobiosis in an African chironomid, *Polypedilum vanderplanki*"*Proceedings of the National Academy of Sciences of the United States of America* 105(13):5093-5098 (2008)
- Y.Nakahara, Watanabe M, Fujita A, Kanamori Y, Tanaka D, Iwata K, Furuki T, Sakurai M, Kikawada T, Okuda T "Effects of dehydration rate on physiological responses and survival after rehydration in larvae of the anhydrobiotic chironomid" *Journal of Insect Physiology* 54(8): 1220-1225 (2008)
- T.Kikawada, Saito, A., Kanamori, Y., Fujita, M., Snigórska, K., Watanabe, M. Okuda, T."Dehydration-inducible changes in expression of two aquaporins in the sleeping chironomid, Polypedilum vanderplanki" *Biochimica et Biophysica Acta*1778 (2): 514-520(2008)
- T. Kikawada, Saito A., Kanamori, Y., Nakahara, Y., Iwata, K., Tanaka D., Watanabe M. and Okuda, T. "Trehalose transporter 1, a facilitated and high-capacity trehalose transporter, allows exogenous trehalose uptake into cells" *Proceedings of the National Academy of Sciences of the United States of America* 104(28): 11585-11590 (2007)

Challange to anhydro-preservation of cell line inspired by a desiccation tolerant African insect

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"Life and death are mutually exclusive states". But some organisms which can be completely desiccated, and show no signs of living are nevertheless able to resume active life upon rehydration. This peculiar biological state is termed "anhydrobiosis". Larvae of the Sleeping Chironomid *Polypedilum vanderplanki*, living in temporary rock pools in Africa are able to achieve anhydrobiosis. We have been elucidating the mechanism and found several molecules responsible for the extreme desiccation tolerance such as trehalose, LEA proteins, anti-oxidative molecules, DNA repair enzymes and so on (Fig.1).

Now we are under challenge to establish a anhydro-preservation method of cells or tissues inspired by the desiccation tolerance mechanism of the African midge. As the first step we generated a cell line originated from *P. vanderplanki* embryo, i.e. Pv11 cells which also can stand complete desiccation to such an extent that some cells had survived after rehydration, but none of the cells proliferated. Lately we improved the dehydration method so that we could achieve storage of the Pv11 cells for about 200 days at room temperature and followed by the perfect proliferation upon rehydration (Fig.2). The Pv11 cell line could be an excellent tool for further analysis of desiccation tolerance mechanism and also contributing to applied sciences including establishment of the anhydro-preservation technology.

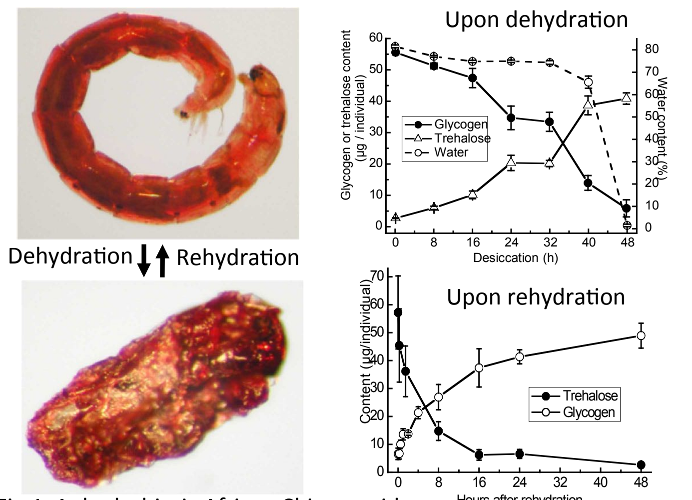

Fig.1 Anhydrobiotic African Chironomid
Significance of trehalose as a compatible solution

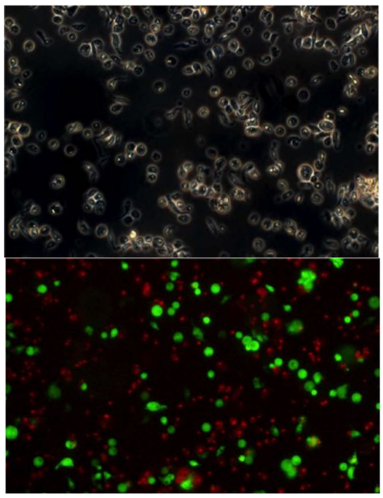

Fig.2 Anhydro-preservable Pv11
Image: 3hrs after rehydration

Stephan Hoornaert

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Education, Academic Background and professional experiences

1996 Licence in Zoological Sciences; End of Study work: « Caractérisation de l'apoptose induite par le virus de l'herpes Bovin-1» (Département d'Immunologie, Faculté de médecine vétérinaire, Liège University, Belgium)
1997-1999 Research assistant. Study of the effect of EMF on foetal rat hippocampus neuron primary culture. (European Graduate School of Neuroscience (EURON) de Maastricht, NL and Neuropharmacology unit, Institut de Pathologie, Liege University, Be)
2000 Certifications in network management: Microsoft Certified Engineer & database management (Centre Corail & IBT, Liège,Be)
2000-2003 Research assistant. Study of the potential inhibitory effect of anti-inflammatory drugs on IL1b production (Unité de recherche sur l'Os et le Cartilage, Institut de Pathologie, Liege University, Be)
2004 Certification in environmental management, End of Study work: « Guide pour un développement durable en milieu urbain» (Haute Ecole Commerciale, Liège)
2005 Creation of the first Apollo prototype "water for all" to produce drinkable water (Matara, Sri Lanka).
2005-2006 Agregation of the superior secondary school (AESS) (University of Liège, Be)
2006 Feasibility study to install a water treatment at the "colline des projets" (NGO Alliance pour un Développement Durable, Kinshasa, R.D.Congo)
2006-2007 Professor of Biology at the secondary level, Collège D.I.C. de Liège
2007-2008 Professor of Sciences at the secondary level, Institut Marie-Thérèse Liège
2009 Formation in communication for environment and sustainable development at the Centre d'Enseignement et de Recherche pour l'Environnement et la Santé (CERES, University of Liège)
2009-2010 Professor at the secondary level, Institut St Remacle Stavelot
2010 English intensive courses, Kaplan International College (Level Advanced, London)
2011 CreaPME Formation: Redaction of a business plan : Apollo & Morpho project in relation with biomimicry
2011-2012 Research assistant at the chemical oceanography unit (department astrophysics, Geomatic and Oceanography (Liege University)
2011-2013 Certification: Help in relationship using touch (Espace de ressourcement, Liege, Be)
2012 Biomimicry consultancy for the Belgian Owl (www.belgianwhisky.com,)
2012 Biomimicry consultancy for Sarah Santin, eco-designer (sarahsantin.be, award from the Walloon region)
2013-2014 Professor of Sciences and Social sciences in immersive courses at the St Louis College (Liege, Be)
2014 Development of the FungiUp project at the Centre de Technologie Agronomique de Stree

Congress and presentations

1996 S. Hoornaert, E. Hanon, M. Lambot & P.P. Pastoret. Congress: "Characterization of Bovine Herpesvirus-1 Induced Apoptosis". Third Benelux congress of zoology (Namur, Be)
1997 S. Hoornaert, D. Terwel, D. Delapierre, H.W.M. Steinbusch & A. Dresse. Presentation: "Effect of electromagnetic fields on brain cells: Study of the expression of c-fos in primary culture". Second scientific meeting of Belgian Bioelectromagnetic group (Bruxelles, Be)
1998 Seminaries: Autumn School Prion's Disease, Alzheimer's Disease, Apoptosis and Cell Death (MRC Cambridge Centre for Brain Repair, Cambridge, UK)
1998 EKN Symposium: Regulation of Synaptic Transmission (Amsterdam, NL)
2005 S. Hoornaert. Exposition: "Sri Lanka: Ceci cela". To finance water analysis in SriLanka (Liège, Be)
2005 O. Bonfond & S. Hoornaert. Presentation: "Le Développement Durable : du Global au Local" (Liège, Be)
2009 S. Hoornaert & S. Dupont. Conference: Introduction à des notions de techniques de relaxation: Le massage cervico-facial et autres techniques de relaxation en rapport avec la respiration et la phonation. (Haute Ecole Robert Schuman, Libramont, Be)
2013 S. Hoornaert & J. Engerisser: Biomimicry and the Blue Economy (Liege, Be)
2014 S. Hoornaert, J.Engerisser & JF Pecheur: FungiUp (Liege, Be)

FungiUp
Cities like forests:
From coffee waste recycling to sustainability!

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In a world of less energy and resources, Biomimicry uses Nature as a Mentor to solve actual problems. Cities may be considered as organisms and the study of its metabolism may lead to systems optimization and sustainability using an ecosystemic approach. The objective is to establish complete ecosystem fulfilling human basic needs (food, drinkable water, energy, oxygen…).

Coffee waste is actually used for the production of high quality mushroom (*Pleurotus ostreatus*). Production may be diversified and other organic waste tested. Champost (rest of mushroom production) is also actually tested for biomethanization, compost production and treatment of polluted soils. The firsts results are promising. Next step is the recycling of containers as urban mushroom production unit toward establishment of complete ecosystems.

This will lead to a better comprehension on how ecosystems works, will help rehabilitating polluted soils and promote sustainability. The positive side effects will be the establishment of innovative processes in urbanization and will also help our comprehension about deep space ecology.

We are looking for partners and funds.

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Education & Academic Background

1979 Graduated from Department of Biology at Yokohama City University
1982 Master of Biology, Marine Biology, Graduate School of Biology, Okayama University
1983 Research Associate, Research Center for Applied Information Sciences, Tohoku University
1989 Visiting Research Fellow of Institute of Australian National University
1990 Doctor of Science, Kyushu University
1990 Visiting Research Fellow of Waikato University (New Zealand)
Research Fellow in Antarctica (Scott Base)
1993 International Centre of Insect Physiology and Ecology (Kenya)
1994 Visiting Research Fellow of Helsinki University (Finland)
1998 Visiting Research Fellow of Groningen University (Nederland)
2001 Associate Professor, Department of Biology, Faculty of Medicine, Hamamatsu University
2002 Visiting Professor of Firenze University (Italy)
2004 Professor, Department of Biology, Faculty of Medicine, Hamamatsu University

Recent Publications

- Y. Takaku, H. Suzuki, I. Ohta, T. Tsutsui, H. Matsumoto, M. Shimomura, T. Hariyama “A 'NanoSuit' surface shield successfully protects organisms in high vacuum: observations on living organisms in an FE-SEM”, Proc. Biol. Sci., 282(1802), pii: 20142857, (2015).
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Biomimetic thin membrane, the NanoSuit®, enhancing surface shield effect for living organism in high vacuo

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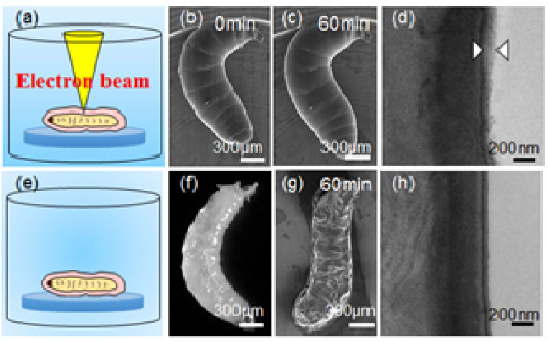
Scanning electron microscopy (SEM) has made remarkable progress, and has become an essential tool for observing biological materials. However, they are required to be completely dry, since the specimen chamber is at high vacuum. The living soft-bodied organisms require chemical fixation and following various complex procedures to preserve and stabilize their structure. Here we demonstrate a new method with which living organisms can be observed by a field emission SEM. Using this method, active movements of living animals were observed in vacuo (10^{-3}-10^{-7} Pa) by protecting them with a coating of “biomimetic thin membrane”, the NanoSuit®, and it was found that the surface fine structure of living organisms is very different from that of traditionally treated samples. The “biomimetic thin membrane” acts as a flexible ‘Nano-spacesuit’ barrier to the passage of gases and liquids and thus protects the organism. After observation of living organisms, despite the high vacuum it was possible to rear many of them subsequently in normal culture conditions. This method will be useful for numerous applications, particularly for electron microscopic observations in the life sciences.



A living *Drosophila* larva was exposed in high vacuo and showed active movement for 60 min (a-c). Before SEM observation, a different larva (light micrograph in (f)) was introduced into the observation chamber without electron-beam irradiation. It was collapsed thoroughly when observed by SEM subsequently (g). TEM images of vertical sections through the surface of each animal are shown in (d) and (h). The layer between the arrowheads in (d) shows the newly formed outer membrane, not present in (h).

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Education & Academic Background

1965	Natural Sciences, University of Cambridge	BA (2i)
1968	Insect Physiology, University of Sheffield	PhD
1968	Lecturer in Zoology, University of Reading	
1970	Elected Fellow of the Royal Entomological Society	FRES
1971	University of Cambridge	MA
1982	Studies on Insect Cuticle, University of Sheffield	DSc
1987	Professional Member, Member of The Institute of Materials	MIM^3
1990	Prince of Wales Environmental Innovation Award	
1991	Established Centre for Biomimetics (with G Jeronimidis)	
1993	Senior Lecturer, University of Reading	
1998	Part-time Lecturer, Royal College of Art	
1997	Elected Fellow of the Royal Society of the Arts	FRSA
1999	Professor of Biomimetics, University of Reading	
2000	Professor of Mechanical Engineering, University of Bath	
2001	Director, Centre for Biomimetic and Natural Technologies, U. Bath	
2004	Honorary Professor of the University of Jilin, China	
2007	Avocational Lecturer at the Steinbeis University, Berlin	
	Appointed as a Chartered Engineer	CEng
	Admitted to Fellowship of the Institute of Mechanical Engineers	FIMechE
2010	First President of the International Society of Bionic Engineering	
2011	Mount Changbai Friendship Award, Jilin Province, China	
2014	Honorary Professor of Bionics, HochSchüle Rhein-Waal	
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Recent Publications

P Riggs, A Bowyer & JFV Vincent (2010). Advantages of a biomimetic stiffness profile in pitching flexible fin propulsion. *J. Bionic Engng.* **7**, 113-119.
JFV Vincent (2010). New materials and natural design. In *Bulletproof Feathers* (ed. R Allen). University of Chicago Press, pp. 132-171.
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Trade-offs, evolution and biomimetics

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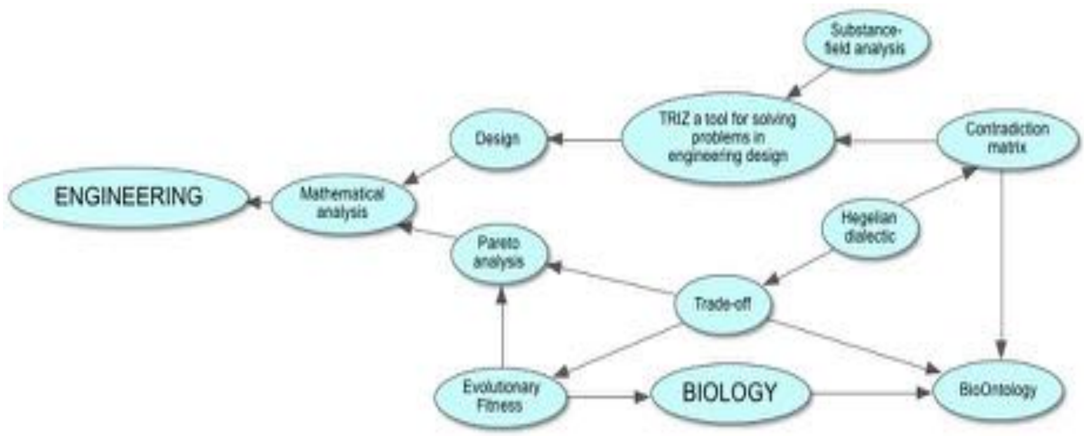
The idea of a trade-off goes back to the ancient Greeks, when Heraclitus pointed out that it was the basis of defining a problem. Hegel called it the dialectic, Engels used the idea to model evolution and Marx applied it to economics. At some point Pareto pointed out that it was something to do with optimisation, and Genrich Altshuller used the same notion in his formulation of TRIZ (Theory of Solving Problems Inventively). The Pareto set is being introduced into ecological theory to model adaptive evolution and (almost) to define "ecological niches" as a series of mutually exclusive trade-offs, which can co-exist in any number. With such a broad set of applications, it should come as no surprise that the trade-off can form the basis of a means of equating biology and engineering, yielding a tool to describe and analyse biomimetics. I'm doing this by generating an ontology, based on TRIZ. Part of the outcome is a series of recommendations for making engineering 'greener'.



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Education & Academic Background

1980 Master course of Aeronautical Engineering, Kyoto University
1980-1988 Research Associate, Department of Aeronautical Engineering, National Defense Academy
1983-1987 PhD course in Department of Engineering, Reading University, U.K.
1987 PhD from Reading University
1988-2003 Associate Professor, Department of Mechanical Systems Eng., Muroran Institute of Technology
1996 Visiting Researcher, Biomimetics Centre of Reading University, U.K.
2003- Professor, Department of Mechanical Science and Bioengineering, Graduate School of Engineering Science, Osaka University

Award: 2010 Award of JSMS Committee on Impact
2006 Light Metal Paper Prize, The Japan Institute of Light Metals

Recent Publications

- H. Kobayashi, K. Horikawa, K. Ogawa, K. Watanabe, “Impact compressive and bending behavior of rocks accompanied by electromagnetic phenomena”, Phil. Trans. R. Soc. A, 372, 20130292 (2014)
- H. Kobayashi1, T. Yamauchi, K. Horikawa, “Mechanical Characteristics of Materials and Structure of Giant Water Lilly Leaf”, 15th IUMRS-Int. Conf. in Asia (IUMRS-IC2014), Fukuoka, August 24-30, 2014
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A Study of Lily Flower Bud from Mechanical Point of View

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The bud of lily flower has two contradicting roles, one is the role to protect firmly the inside stamen and pistil from the outside environment, the other is to expose them to outside safely at flowering. It is very interesting how lily flower performs these contradicting roles.

In this study, the bud of lily was observed by using X-ray CT and optical microscope and projecror, as shown in Fig.1. One of the most interesting things is that the edges of sepals run into the tiny space between petal rib and petal surface. This petal-sepal assembly structure seems to give a good hermetic sealing and to make the protection strong against external environment forces. From the observation, it was found that the sepal is wrapped up inward when it was artificially removed from the fixation parts before flowering (see Fig.1(c)). This phenomenon gradually becomes small when the bud grows in length. In order to examine the meanings of this change, FEM analysis was carried out.

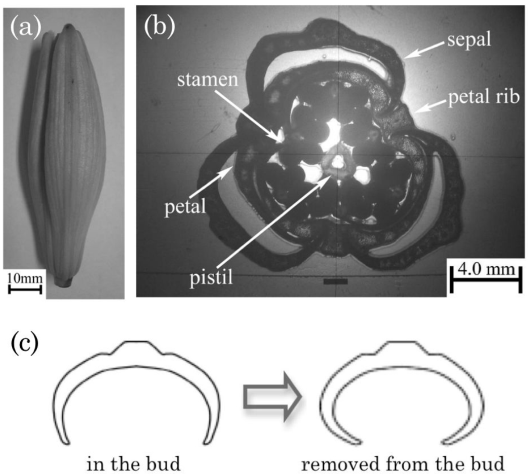

Fig. 1 Bud of lily flower: (a) side view of bud, (b) cross section of bud and (c) shape change of sepal cross section from situation in the bud to situation removed from bud.

The mechanical characteristics of peral and sepal were investigated by tensile tests to use the data in FEM analysis. Two types of tensile specimen were prepared. One is L-specimen whose longer side is parallel to the longitudinal direction of petal, and the other one is T-specimen whose longer side is parallel to the transverse direction of petal. From Fig.2, it can be clearly found that the stiffness of petals in the L-direction is more than twice of that of T-pecimen.

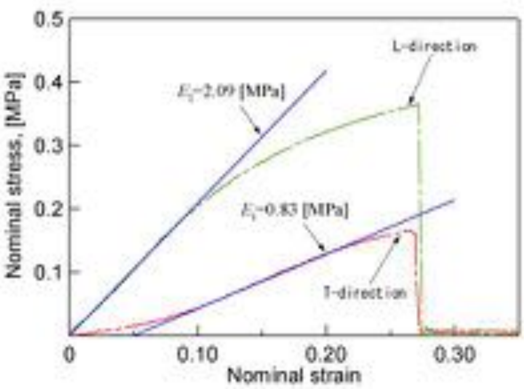

Fig.2 Stress-strain curves of sepal and petal of lily.

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2008 Cofounder and CEO of Biomimicry IL (NGO)
2010 Lecturer of the course "Biomimicry and Organizations", The IDC Interdisciplinary academic center, Herzliya
2010-15 Editor of the Israeli biomimetic on-line journal
2012-15 Member of the Biomimetic ISO international committee, representative of Israel
2013 Seminar "From Bio-Engineering to Biomimetics, Some contributions of Design theory", MINES ParisTech
2014 Head of biomimicry Lab, Tel Aviv University
2014-15 Initiator and organizer or the yearly conference: "Biomimicry-Academy and Industry"
2015 Ph.D in Biomimetic Design, The porter school of environmental studies, Tel-Aviv University. Research title: "Biomimicry design method for innovation and sustainability"
2015 Lecturer of the course "Bioinspired Innovation", ECAST- East China University of Science and Technology, School of Business

Recent Publications

- Helfman, C.Y., Reich, Y., Introduction of the ideality tool for sustainable design. The 20th International Conference on Engineering Design (ICED), Milano, 2015.
- Weiss, A., Iko, A., Helfman Cohen, Y., Das Amarendra, K., Mazor, G., The ideality what model for product design, in 17th International conference on engineering and product design education, Loughborough, 2015
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- Helfman, C.Y., Reich, Y., Greenberg. S., Substance field analysis and biological functions, in ETRIA TRIZ future conference, Lisbon, 2012.
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Introduction of the Structural Biomimetic Design Method

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Understanding the relationships between structures and functions is important for engineering design in general and for biomimetic design specifically. In nature, different structures provide a wide range of functions efficiently and with minimal costs. Based on the analyses of 140 biological systems that are derived from biomimetic sources by a TRIZ based method, we provide a list and examples of structure–function patterns that repeat in biomimetic applications. These patterns are presented through a technical lens and a complete system model, serving as engines or brakes of the biological system, exploiting energy sources or blocking them, respectively.
This list of structure-function patterns in nature is the core of the structural biomimetic design method, a platform to lead a systematic biomimetic design process.
The list provides both keywords for search in general biological databases and mainly leads the search in the FindStructure database, a unique and novel biomimetic database that organizes biological systems not only by functions but also by structures.
These structure-function patterns are integrated in a TRIZ system modeling tool, the law of system completeness, providing an abstraction platform for biological knowledge. Sustainability patterns that are also addressed by this design method are beyond the scope of this presentation.
Altogether, the structural biomimetic design method suggests a clear design algorithm and tools to transfer knowledge form biology to technology and to promote innovative sustainable designs.

Table 1 The patterns table: list of structure–function patterns

	Structural Pattern	Types / Private cases	Generic Function	Generic Functions (second hierarchy)	Generic Functions (third hierarchy)
1	Repeated protrusions		Move (Engines)	Attach	Connect, Combine, Join, Adhere, Bond, Add, Increase
				Detach	Remove, Subtract, Decrease
2	Repeated tubes / Channels	Without Valves		Channel	Lead, Guide, Direct, Flow, Stream, Transfer
		With Valves		Regulate	Control, Modulate, Separate, Filter
3	Asymmetry	Geometric Asymmetry		Change	Change position or location: Rotate, Spin, Turn, Move up, Move down, Open, Close
		Material Asymmetry			
		Time Asymmetry			Change volume or form: Blow, Blast, Cut
4	Layers (Sandwich)		Stop (Brakes)	Protect or defend against mechanical or thermal loads	Absorb, Push back, Resist, Isolate, Insulate (heat)
5	Intersected layers	Network, Cellular, Honeycomb			
6	Tube				
7	Helix				
8	Streamlined shapes	Spiral, beak & Body contours		Protect or defend against dynamic loads (turbulences)	Stabilize, Disperse, Deflect, Smoothen
9	Container	Sphere, Cups		Protect or defend against gravitation and / or mechanical loads	Contain, Store, Hold, Grasp, Trap

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Education & Academic Background

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2005 MS, Department of Mechano-Informatics, Graduate School of Information Science and Technology, The University of Tokyo
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2006-2009 Research Fellow of the Japan Society for the Promotion of Science (DC1), Department of Mechano-Informatics, Graduate School of Information Science and Technology, The University of Tokyo
2009-2011 Postdoctoral Fellow, Harvard School of Engineering and Applied Sciences, Wyss Institute for Biologically Inspired Engineering at Harvard
2011-Present Research Assistant Professor, Chiba University

Award:
2008 Young Scientist Award 2nd Prize in SEB2008, Marseille, France.
2008 Student Presentation Award in 40th Fluid Dynamics Conference/Aerospace Numerical Simulation Symposium (in Japanese), Sendai, Japan
2013 General Biomechanics Best Poster 3rd Prize in SEB2013, Valencia, Spain

Recent Publications

- H. Tanaka, H. Okada, Y. Shimasue, H. Liu, “Flexible flapping wings with self-organized microwrinkles,” Bioinspiration & Biomimetics, 10, 046005, (2015).
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Aerodynamic characteristics of flat-plate wings with serrated leading edges modeled on an Ural owl's primary feather

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Owls are birds of prey well known for their capablitiy of silent flight. The wings posess distinctive serrations at the leading edge, which are frequently assumed to be a key-appratus for the silent flight. The leading-edge serrations, however, could control airflow around the wings for flight behavior rathar than noise reduction, and the actual functions of the leading-edge serrations are still controversial. In this study, aerodynamic force measurement and PIV (Particle Image Velocimetry) of the 10th primary feather (the leading-edge feather of the wing) of an Ural owl and artificial feather models were performed in a wind tunnel to investigate the aerodynamic effects of the leading-edge serrations of the owl wings. The mean chord length of the owl feather used here was 28.6 mm and that of the models was 30 mm. The lengths of the artificial serrations were 0, 3, 6 mm and the spacing was 1 mm (**figure 1**). The wind velocity was set at 3 and 5 m/s. The force measurements revealed that lift slopes (a slope of a lift coefficient to angle of attack curve) of both the owl feather and the artificial models with serrations were moderate, while that of the model without serrations showed rapid change around 10-degrees angle of attack. The PIV results demonstrated that the serrations suppressed velocity fluctuations in separated flow when the angle of attack was larger than 10 degrees (**figure 2**). These results indicate that the leading-edge serrations are likely capable to enhance the robustness of the lift generation at large angle of attack.

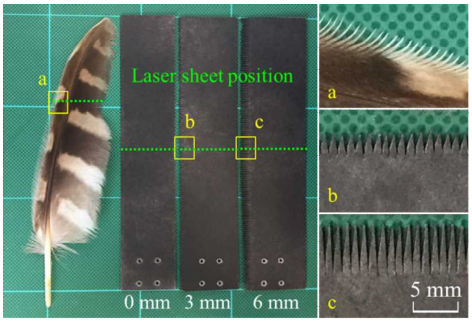

Figure 1 10th primary feather of an ural owl and artificial feathers

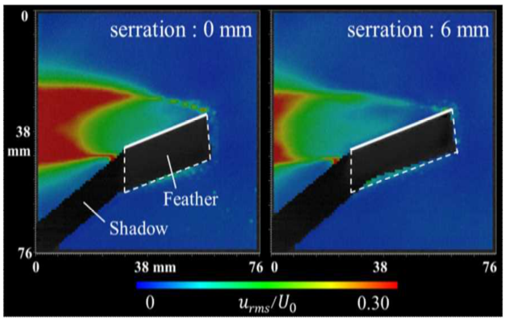

Figure 2 Velocity fluctuations around the artificial feather with 0-mm and 6-mm serrations. Angle of attack was 20°.

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Education & Academic Background

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2006, Junior Researcher, University of Ljubljana, Ljubljana, Slovenia
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2009, Senior researcher, Laboratory of Biomechanics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Prague, Czech Republic
2011, Fullbright Visiting Scholar, University if Iowa, Iowa, USA
2014-, head of Laboratory of Biomechanics, Faculty of Mechanical Engineering, Czech Technical University in Prague, Prague, Czech Republic
2009-, Bulletin of Applied Mechanics, editor-in-chief
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Awards:
Slovak Medical Society, Medal for biomechanics development, Bratislava, Slovakia, 2011
Societe Internationale de Recherche Orthopedique et de Traumatologie, Poster Award, Buenos Aires, Argentina, 2006
Siemens AG, Werner von Siemens Excellence Award, Prague, Czech Republic, 2005
Zvonicek Foundation, 1st prize of the Zvonicek Foundation for the best doctoral thesis, Prague, Czech Republic, 2005
Human Biomechanics Foundation, Prize of Prof. Valenta and Prof. Cihak for a young researcher in biomechanics, Prague, Czech Republic, 2004

Recent Publications

- Horný, L. - Netušil, M. - Daniel, M.: Limiting extensibility constitutive model with distributed fibre orientations and ageing of abdominal aorta. Journal of the Mechanical Behavior of Biomedical Materials. 2014, vol. 38, p. 39-51.
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Biomimetic design of hip joint replacement

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Primary and revision joint replacement market growth is expected to be driven by increasing demand for joint replacements as the “baby boom” generation nears retirement and an increasing number of younger patients undergo joint replacement procedures. Today orthopedic joint replacement market is at a crossroads between time-tested conventional procedures with limited lifetime and advanced implant design and materials to match these socioeconomical changes.

The possible way how to address these challenges is to apply methods of biomimetic design. The field of arthroplasty strongly need a multidisciplinary approach based on better understanding the natural design of physiological synovial joint and application of these methods in artificial joint replacement using advanced engineering materials and designs. The aim of this lecture is to present selected problems of hip arthroplasty at various levels: from whole joint replacement to tissue-surface interaction and their possible solutions originating from biomimetic design.

Two principal problems of joint replacement are discussed: stress shielding and polyethylene wear. Stress shielding in femur occurs when some of the loads are taken by prosthesis and shielded from going to the bone. Femur bone remodeling and bone loss occurs after hip replacement surgery as a result of bone unloading. Bone loss and cortical thinning eventually lead to joint prosthesis failure. Therefore a prosthesis that would restore normal force transfer in hip joint is required. There exists two principle solutions: either shorter femoral stem that would restore normal load to the rest of the femur or biomimetic material that would match the bone stiffness. Each of the following solution has its disadvantages and the possible solution may be in application of novel design drawn after consideration of healing phenomena in bone.

Another great problem in joint replacement is wear. Wear in total joint replacements is caused by relative motion under load at articulating surfaces or at interfaces between modular metal-on-polyethylene components. Osteolysis induced by particulate wear debris from implant materials has been recognized as the major cause of long-term failure in total joint replacements. However, the development of preventive measures for this phenomenon has not been successful because the mechanism in which wear particles cause osteolysis is not quite clear. The possible solution would be in further understanding of natural hip contact mechanics that is far from ball-and socket joint of joint replacement and application of design that would mimic this mechanics.

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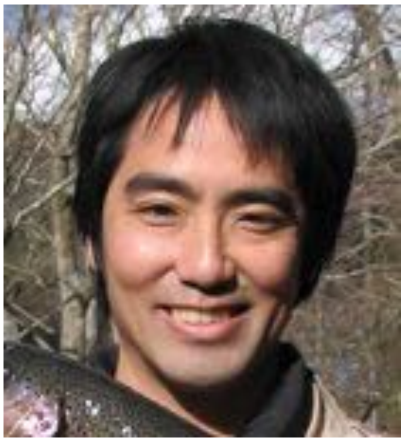

Education & Academic Background

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2000	Doctor of Engineering, Tokyo Institute of Technology
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2007-2010	Researcher, Nanotechnology Research Institute (Kansai), National Institute of Advanced Industrial Science and Technology (AIST), Japan
2010-2014	Group Leader, Soft Mechanics Group, Nanosystem Research Institute (NRI), AIST, Japan
2014-2015	R&D Division, Industrial Science and Technology Policy and Environment Bureau, Ministry of Economy (METI), Japan
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Recent Publications

- T. Ohzono, T. Yamamoto, J. Fukuda, “Liquid Crystalline Chirality Balance for Vapours” Nat. Commun. 5, 3755, 2014.
- K. Suzuki, Y. Hirai, T. Ohzono, “Oscillating Friction on Shape-Tunable Wrinkles” ACS Appl. Mater. Interface, 6, 10121, 2014.
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Sliding Friction on Shape-Tunable Wrinkles

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The excellent performance of soft-microstructures on living surfaces in terms of their adhesion and friction has attracted considerable attention, as these are key elements in many tribological applications. The enhanced adhesion and reversible control of gripping in living surfaces are attributed to the deformation of the soft-microstructures in the attachment surface (e.g., seta, spatula, hexagonal cell, and fingerprint). Herein, we consider a system, in which a soft-microstructure is dynamically tunable, to further explore the possibility of dynamic controlling of, e.g., friction, adhesion, and lubrication. As a model system of the shape-tunable soft-microstructures found in living systems, the buckling-induced wrinkles are attracted attention, which is generated on a compressed elastomer having a hard top layer. The wrinkles show a wide variety of periodically-undulated structures, depending on the material, while also allowing the alignment direction of the grooves (or crests) and the sinusoidal shape to be varied.

On this point of view here we show recent results of friction experiments on two different wrinkled surfaces; wrinkles on a polyimide (PI) film atatched to a polydimethylsiloxane (PDMS) elastomer with the wrinkle wavelength of hundreds of micrometers: PI-system [1], and those on a PDMS surface, underneath which a microporous film is embedded to harden the surface effectively, with the wrinkle wavelength of tens of micrometers: PDMS-system [2,3]. In both cases the anisotropic wrinkles can be induced by adding strain and the amplitude are tunable in a certain range. The main difference of two experimental systems is the scale of the wrinkle periodicity. Using an indentor for the friction tests as the counter slider having a round shape with the diameter of 1 mm for PI-system or of 5 mm for PDMS one, different frictional results are expected on two wrinkle systems because the size of the indentor is comparable to that of the wrinkle periodicity for the PI wrinkles and is much larger for the PDMS wrinkles.

The main results of the normal-load-dependent average friction forces on the wrinkled and the flat surfaces are shown in Figure 1. On the PI surface the friction force increases (~+20%) when the surface is wrinkled (Figure 1a). On the other hand, the friction decreases on the PDMS surface (~-20%) when the surface is wrinkled (Figure 1b). On the PI wrinkles, the indenter tip can be stacked between the crests of wrinkles during the sliding and expect the resistance from one crest ahead to lay over it. This may be explained by so-called Coulombic interlocking and/or the elastic plowing mechanism [1 and references therein]. On the PDMS wrinkles, however, the indenter must make contacts with multiple wrinkle crests. Consequently, the total area of contacts decreases and the stick-slip event becomes easy to occur, leading to reduction of friction through the Bowden-Tabor's adhesive friction model [3]. We believe that these results will be helpful to understanding and analyzing the tribological phenomena associated with soft deformable living surfaces, as well as the development of new mechanically-functional surfaces for soft composite materials.

We thank KAKENHI (Grant No. 24120003) for their supports.

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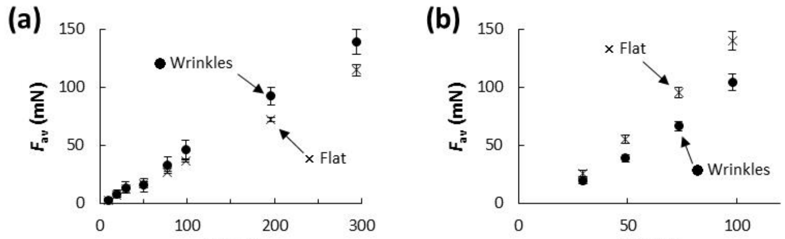

Figure 1. Average friction force F_{av} vs. normal load P on wrinkled and unrwrinkled (flat) surfaces. (a) PI-surface. (b) PDMS-surface.

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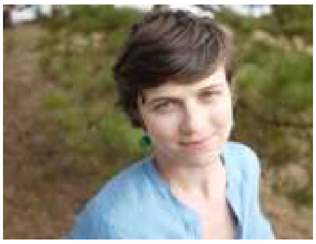

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2005- 2009	RESEARCH FELLOW – PIERRE ET MARIE CURIE UNIVERSITY - PARIS PhD in Neurosciences
2006-2009	TEACHING Pierre et Marie Curie University & ESPCI Engineering School - Paris
2012-2014	BIOMIMICRY AND RESPONSIBLE INNOVATION IN SMEs – PARIS REGION INNOVATION CENTER - www.innovation-idf.org
Since 2014-02	RESPONSIBLE FOR THE SCIENTIFIC DEVELOPMENT OF THE CEEBIOS

OTHER RELATED ACTIVITIES

Since 2010	VOLUNTEER – BIOMIMICRY EUROPA FRENCH COMITEE - www.biomimicry.eu Conferences for corporations, universities and engineering schools. Involvement in exhibitions and regular events, animation and network expansion.
Since 2012	Expert member of the ISO TC 266 Biomimetics
Since 2013	Editorial advisor for the French « Techniques de l'Ingénieur » journal
2014	Expert for the European Commission – Nature Based Solutions

Bio-inspired innovation implementation in R&D strategies - A French landscape overview

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In order to face societal challenges, new trans-disciplinary and trans-sectorial approaches have become essential to conciliate human society prosperity, resources conservation and the decrease of human activity impacts over the long term. These innovative approaches should involve most of the scientific and social disciplines, as well as actors from private, public and political sectors.
In this context, bio-inspired innovation is one of the most promising approaches. This strategy takes advantage of living technologies (chemistry, materials, processes…) and systems, selected by 3.8 billion years of adaptation and evolution in order to develop new innovative products, services and organizational models.

Several scientific and methodological obstacles and hurdles regarding bioinspiration integration still remain to be overcome. In order to go beyond isolated and singular initiatives, it is required to analyze the mechanisms of biological knowledge transfer: case studies should allow to experiment and develop systematic tools to introduce biomimicry in R&D&I processes by setting up trans-disciplinar networks and teams. Furthermore, promoting the integration of this approach as a driver of responsible innovation by entrepreneurs, industries, local authorities, educators and political actors, but also its assimilation by the civil society (citizens, consumers ...) is still necessary.

In September 2012, the City of Senlis, 40 km north of Paris, decided to convert an ancient military site into a center dedicated to bio-inspiration. Covering 10 hectares, the CEEBIOS, Centre Européen d'Excellence en Biomimétisme de Senlis, aims at becoming a campus that will gather research and higher education activities, innovative start-ups using bio-inspiration, SMEs but also major industrial groups.

Engineering Neo-Biomimetics
平成24年度科学研究費補助金 新学術領域研究(研究領域提案型)
生物多様性を規範とする革新的材料技術
Innovative Materials Engineering Based on Biological Diversity

Preliminary Study on 3D Data Sampling for Internal Morphology of Insects


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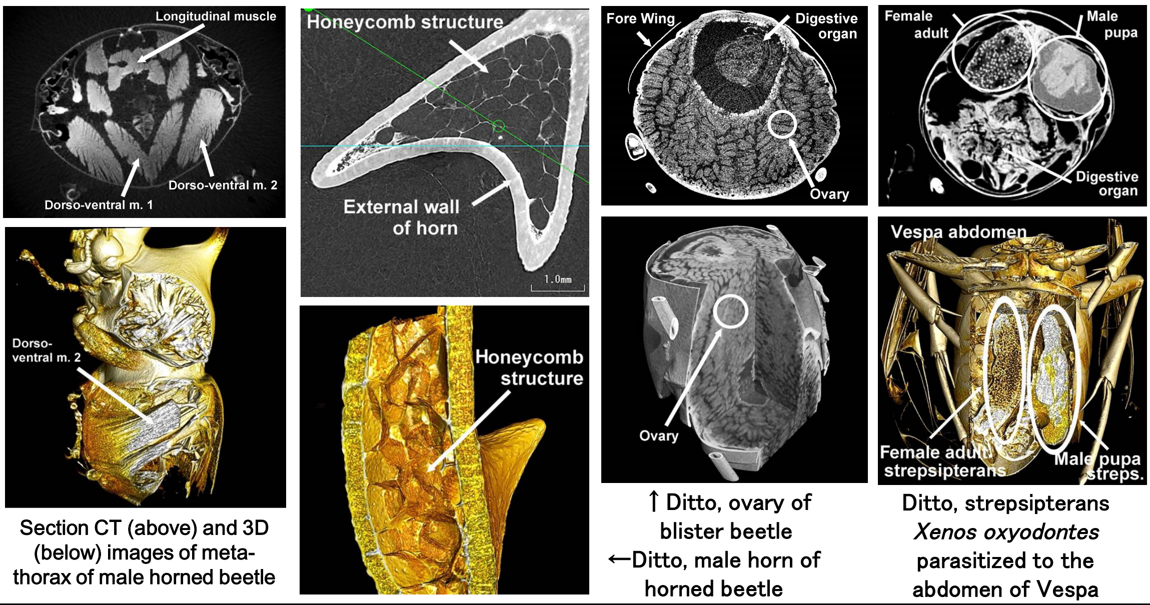
Background

In the course of insect morphology, internal morphology on the system of muscles and viscera have been observed and measured only by destructive methods, for example dissection or preparation. In this study, non-destructive 3D sampling on the thorax of male horned beetle and the ovary of blister beetle were made by a micro-focused X-ray CT, SHIMADZU inspeXio SMX-100CT.

Additionally, the external and internal structures of strepsipterans, *Xenos oxyodontes* (Insecta, Strepsiptera) parasitized to the abdomen of *Vespa simillina* were observed and correctly recorded.

Results



Section CT (above) and 3D (below) images of meta-thorax of male horned beetle

↑ Ditto, ovary of blister beetle
←Ditto, male horn of horned beetle

Ditto, strepsipterans *Xenos oxyodontes* parasitized to the abdomen of Vespa

In the thorax of horned beetle, structures and positions of flight muscles driving the hind wing were correctly recorded. In the head horn, the external wall and the internal honeycomb structure could be observed non-destructively. In the ovary of blister beetle, positions of digestive organ and ovary, and arrangement of eggs were recorded. The position and the shape of male and female of strepsipterans, *Xenos oxyodontes* parasitized to the abdomen of *Vespa simillina* were non-destructively observedand recorded. On the other hand, difficulty for minute and thin parts, and weak resolution of the micro-focused X-ray CT for ultrastructure were found.

Key words
・micro-focused X-ray CT
・3D data
・internal structure

Summary

Internal structures of three species of insects were observed and recorded non-destructively by a micro-focused X-ray CT. This method is very effective for macro-structures, for example, flight muscles, digestive organs and ovary. But weak point of the CT for microstructures were also recognized.

平成24年度科学研究費補助金 新学術領域研究(研究領域提案型)

Engineering Neo-Biomimetics

生物多様性を規範とする革新的材料技術

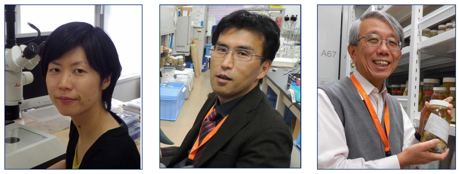
Innovative Materials Engineering Based on Biological Diversity

The surface structures of suckers and paired-fin pads in teleostean fishes

Eri Katayama, Gento Shinohara and Keiichi Matsuura

➢ Fish collection of NSMT: great resource for biomimetics

- There are over 3 million wet specimens (preserved in alcohol) in NSMT. SEM images of the fish skins have been produced from the fish specimens.
- Using such images and the ecological keywords, we are developing the Biomimetics Database in cooperation with IT researchers.
- We are also studying the functional morphology together with engineering researchers.



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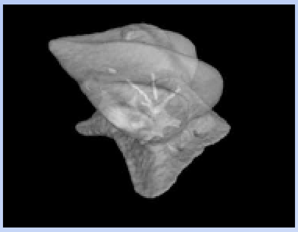
➢ Morphology of shark skin (placoid scale) and ecology of shark

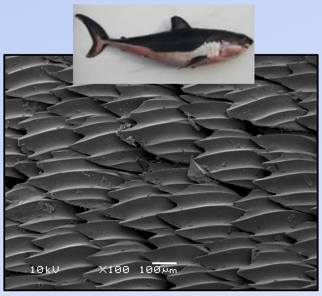
A placoid scale of shark



The image of a scale of Nurse sharks by inspeXio SMX-100CT (Shimadzu Excellence in Science)

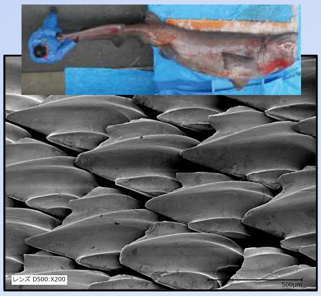
Sharks: about 400 species

● Mackerel sharks
(Lamnidae: *Lamna ditropis*)



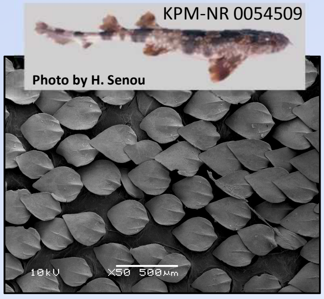
Open ocean & fast swimming

● Cow sharks
(Hexanchidae: *Hexanchus griseus*)



Deep waters & bottom dwelling (slow swimming)

● Carpet sharks
(Orectolobidae: *Orectolobus japonicus*)



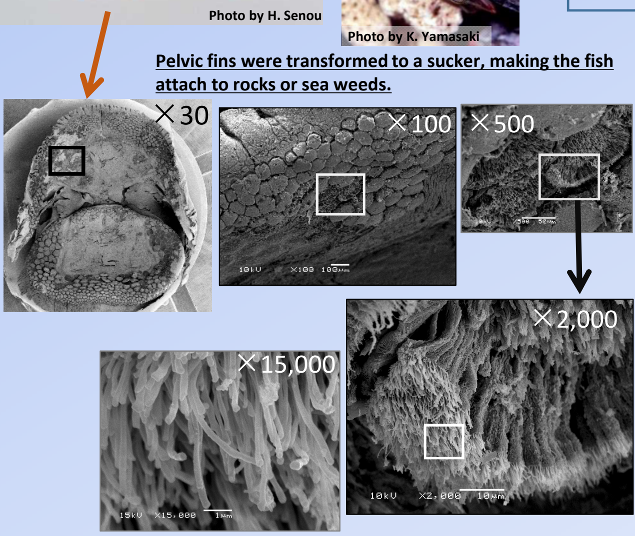
Bottom dwelling (not fast swimming)

➢ Diversity of the sucker and suction fins

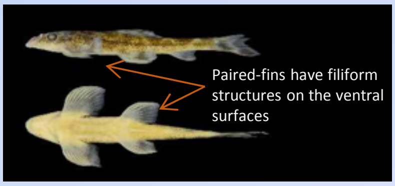
● Cling fishes (Gobiesocidae*: *Aspasmichthys ciconiae*)

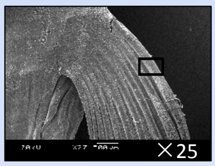
*Perciformes: about 10,000 species
**Cypriniformes: about 3,500 species

Pelvic fins were transformed to a sucker, making the fish attach to rocks or sea weeds.

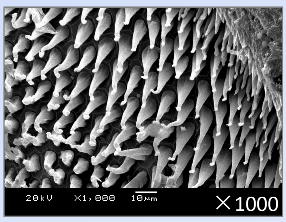


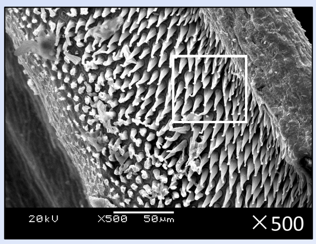
● Flat loaches (Balitoridae** : *Balitoropsis leonardi*)





Pectoral and pelvic fins have filiform surfaces, making the fish attach to the bottom of river.





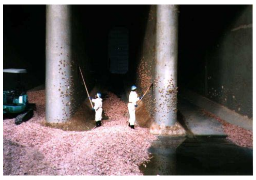
KPM-NR: photos from Fish PIX of the Kanagawa Prefectural Museum of Natural History / *Lamna ditropis*, photo by F. Tashiro

～Development of Antifouling Functional Surface using Biomimicking Microstructure～

Purpose

Excessive growth of fouling organisms on such as ship hulls, fisheries nets and power plants causes technical and economic problem worldwide. To prevent settlement of sessile organisms, paints containing organotin compounds and cuprous oxide compounds have been commonly used. However, the use of these metal-based compounds has been brought to public attention by many reports of environmental contamination. Therefore, antifouling technologies that are not only effective and but also environmentally friendly are urgently needed.

In this research, we are trying to develop new type antifouling surface applying microstructure and chemical modification technology by mimicking marine organisms, such as sharks and dolphins.



Power plant

Ship hull

Contact Persons
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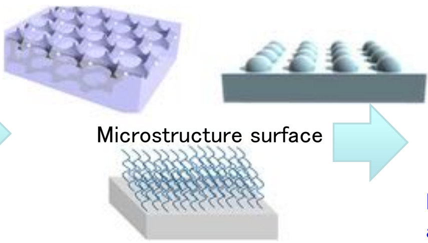
noga@criepi.denken.or.jp

Concepts of our research

Model surface of sharks and dolphins skins

Investigation of relationship between microstructure and antifouling effect



Microstructure surface

Surface with chemical modification

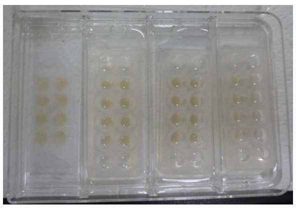
Evaluate antifouling effects

Development of new type antifouling surface from mimicking marine organisms

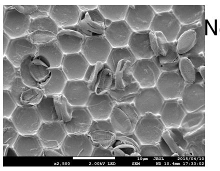
Research Details

Evaluation of antifouling effects of microstructure using several fouling organisms

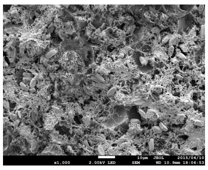
Settlement test using diatoms



Incubate for one week



5 µm pillar structure



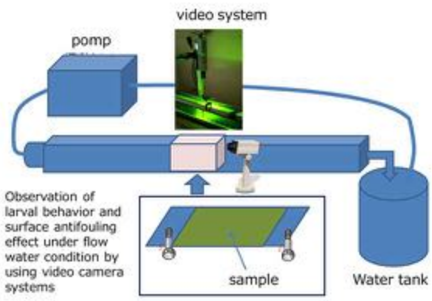
15 µm pillar structure

New test systems using flow water

Barnacle larvae

Adult barnacles

The previous assay methods is tested in still water situation



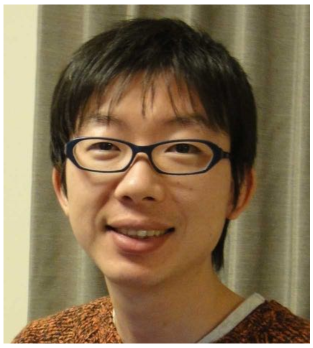
Summary

In order to development of environmental friendly antifouling surface, it is important to develop antifouling evaluation methods using some fouling organisms and flow water condition

Self-Adjustable Adhesion of Polyampholyte Hydrogels

●Introduction

Bacteria cells can attach with almost any surfaces, regardless the diversity in the surface chemistry. The self-adjustable capability of the extracellular polymeric matrix (EPM) of bacteria cells has made this possible. Inspired from nature, we intend to find out a self-adjustable hydrogel adhesive for adhesion to hydrogels and tissues. A self-adjustable surface is such a surface which can offer its species for the formation of attractive interaction depending on substrate charges through dynamic reorganization process. A possible design for achieving such a self-adjustable adhesive is a hydrogel composed of both positively and negatively charged monomers.



•Laboratory of Soft and Wet Matter, Graduate School of Life Science, Hokkaido University, Sapporo, 060-0810, Japan
KUROKAWA Takayuki
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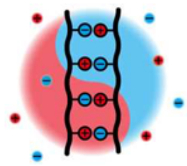
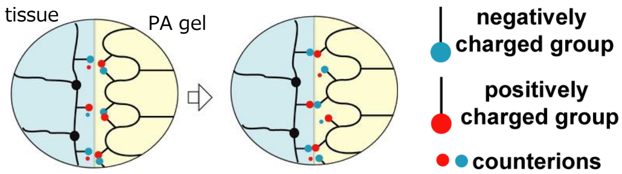


Use polyampholyte based hydrogels as adhesive

Copolymerized from positive and negative monomers

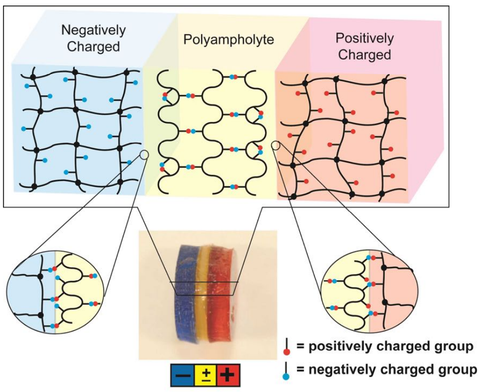
Ion-complex based system



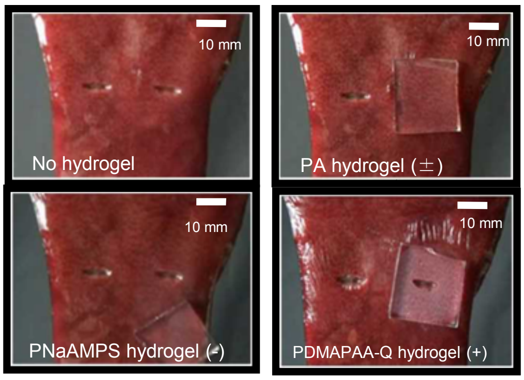
Can form strong ion-complex with either positive charge or negative charge.
Can increase number of adhesion sites through non-specific attractive interaction.

●Results

Self-adjustibility of PA hydrogel for adhesion



PA hydrogel can stick with both positively charged PDMAEA-Q and negatively charged PNaAMPS hydrogels.



PA hydrogel strongly sticks to liver tissue for long time and closes notch.
Negatively charged hydrogel does not stick to tissue surface.
Positively charged hydrogel sticks to tissue surface but fails shortly.

●Summary

A neutral PA hydrogel can act as wet adhesive material for the joining of PE hydrogels or biological tissues based on a self-adjustable ion-bond formation mechanism. This mechanism, driven by the Columbic interaction and the entropy gain of the counter-ion release, is specific for polyelectrolyte systems in aqueous environment.

Multi-Functionalities of Moth-eye Film

Purpose

The living body surface develops many functions with one structure. It is hoped that the structure formed by technique of biomimetics also develops many functions.
We produce the moth-eye type AR films with the roll type molds, continuously. Moth-eye structures can prevent reflection. We have been developing a continuous manufacturing process of moth-eye structures on a polymer film with the roll mold. We verified the multi-functionality of our moth-eye films: reflection, contact angles with water, insect-slipping phenomena.

Contact Persons
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Yokohama Research Laboratories
Dr. Yoshihiro UOZU
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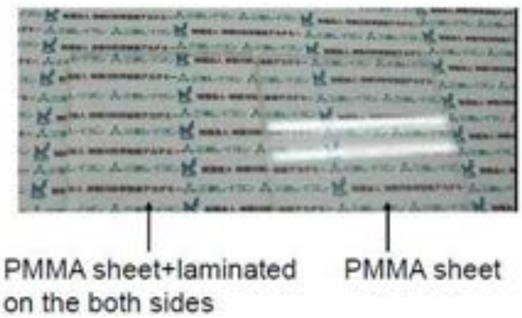
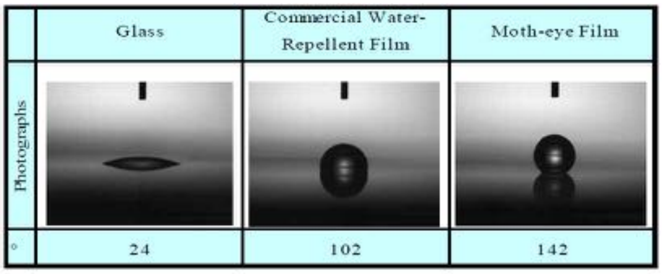
Research Details

As for the moth-eye surface consisting of a hydrophobic polymer, the contact angle of the water is around 140 degrees. On the contrary, the value for a hydrophilic polymer is around 20 degrees. These phenomena reflect characteristics of polymers.
We put an insect on the plastic plate and turned the plastic plate 180 degrees. When the surface was smooth, the insect was getting on the plastic board. In contrast, on the moth-eye surface, the insect slipped down from a plastic board for 90 degrees. Most insects slipped down on moth-eye surfaces.



Reflections of Fluorescent Lamps



with 1μL water

Contact Angles for water

Summary

We have verified the multi-functionality of the moth-eye surface. It is hoped that the structure formed by technique of biomimetics develops many functions.
Acknowledgements: We thank Prof. Hariyama of Hamamatsu University School of Medicine for the observation of insect-slipping phenomena.

～ Formation of corneal nipples in insects ～

Purpose

"Moth-eye structure" which was discovered at the outer surfaces of moth eyes had an array of cuticular protuberances termed "corneal nipples", and was known to serve anti-reflective, self-cleaning and/or water-repellent functions. Although the morphology and function of "moth-eye structure" are relatively studied, the mechanism of the formation is elusive. Elucidation of self-organizing mechanism on nipple formation in insects will inspire us to develop the engineering approach to produce the nanostructured products.

Contact Person：
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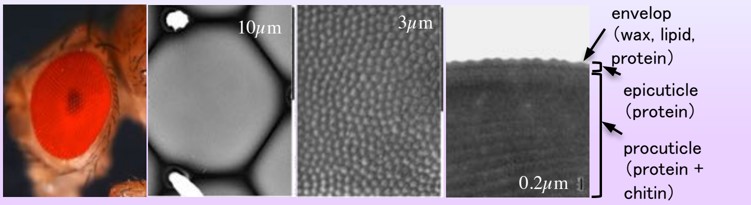
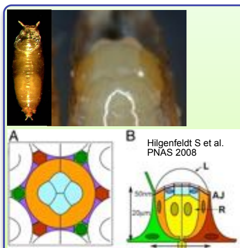


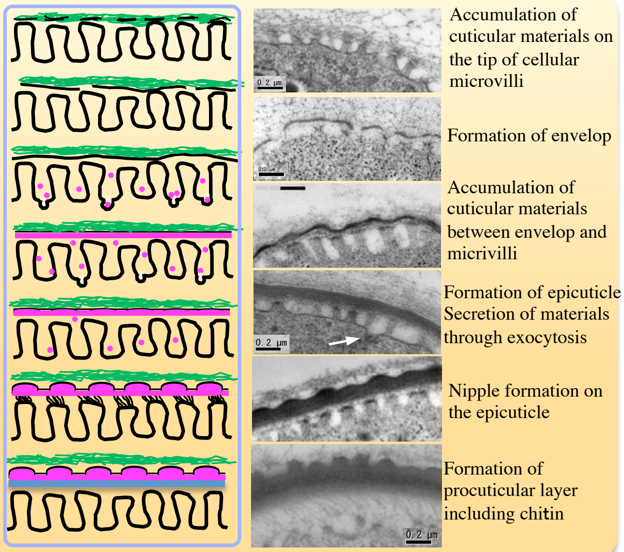
Corneal lens in *Drosophila melanogaster* (nipples on the surface)



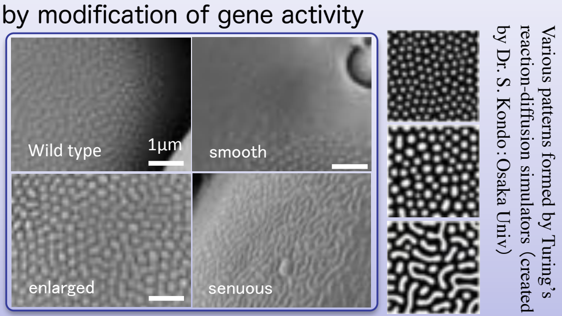
Cuticular materials for corneal lens are produced by
・four cone cells
・two 1ry pigment cells

Corneal lens is formed during pupal stages

Research Details

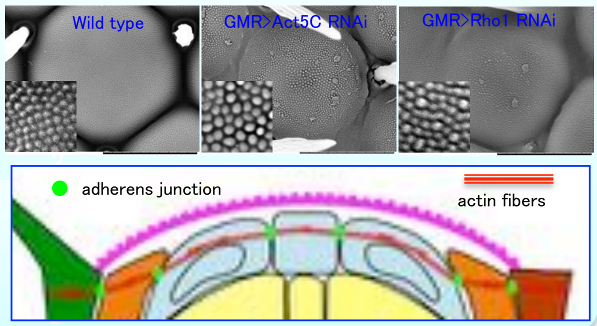


Various nipple patterns are formed by modification of gene activity



self-assembly/self-organization

Changes of apical tension enlarge the size of nipples



Apical tension by actin filaments through cell adhesion apparatus
↓
Tension at the self-organizing region of lens formation
↓
Pattern formation of corneal nipples

Summary

Corneal nipples are formed from cuticular materials secreted by lens cells through exocytosis, probably in self-organizing/self-assembling manners. Modification of some genetic activities changes the pattern of nipples. Apical tension by cytoskeletal actin filaments should affect the tension at organizing region and regulate the size of nipples.

Induction of resistance response of soybean by chemical in the oral secretion of insects

Purpose

It is well-known that insect herbivory commonly elicits rapid plant responses. Similar to many plants, soybean (*Glycine max*) leaves emit volatile terpenes when treated with fatty acid-amino acid conjugate (FAC) elicitors such as volicitin [*N*-(17-hydroxylinolenoyl)-L-glutamine] present in the oral secretions and gut contents of *Spodoptera litura*. However, outside of few investigations, insect-inducible metabolites in soybean remain poorly understood.

The objective of this study was to establish a method to quantitatively evaluate responses of soybean varieties to *S. litura* herbivory. Interestingly, we found that artificial mechanical damage and treatment of extracts of *S. litura* gut contents on Soybean leaves induced the same responses as that induced by *S. litura* herbivory (Fig. 1).

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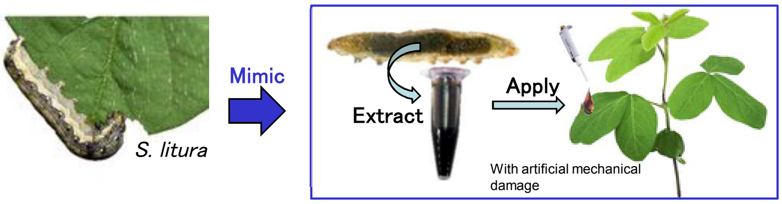

Fig. 1 The mimetic method of *S. litura* herbivory

Research Details

Artificial damage and treatment of the gut content extracts on soybean leaves induced flavonoids, which were induced by the herbivory (Fig. 2) (*Metabolites, 2014*, *4*, 532-546). These metabolites were analyzed by LCMS and PCA.

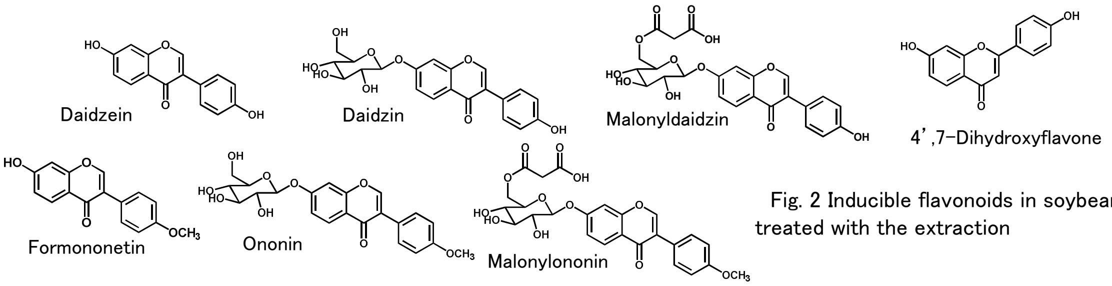

Fig. 2 Inducible flavonoids in soybean leaves treated with the extraction

Moreover, treatment of gut content extracts with $^{13}C_9$-phenylalanine (biosynthesis precursor of flavonoids) showed that labeled phenylalanine was incorporated into formononetin (Fig. 3). Chemicals in the gut contents activate the biosynthesis pathway of flavonoids in soybean.

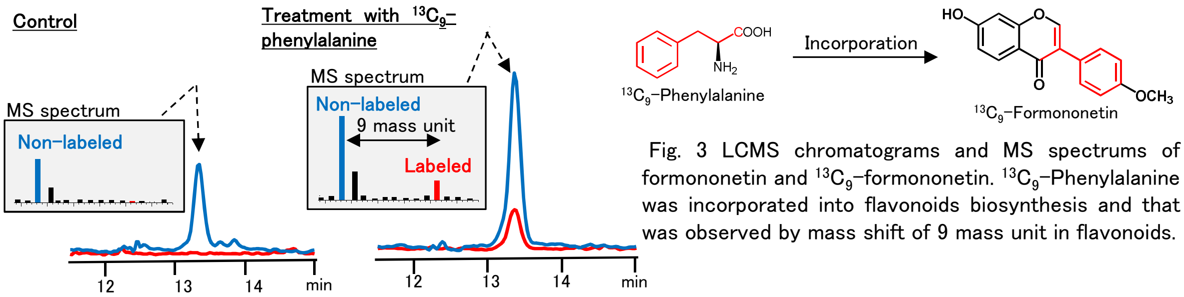

Fig. 3 LCMS chromatograms and MS spectrums of formononetin and $^{13}C_9$-formononetin. $^{13}C_9$-Phenylalanine was incorporated into flavonoids biosynthesis and that was observed by mass shift of 9 mass unit in flavonoids.

Summary

Insect herbivory in soybean can be mimicked by using extracts of the oral secretion and gut contents. By using the extracts, we will study the resistance of soybean to insect herbivory by evaluating the metabolite quantitatively and reveal the molecular basis of the resistance.

～Chemical sensing system learned from ant sensillum～

Mamiko Ozaki, Masaru K. Hojo, Yusuke Takeichi, Dept. Biol., Grad. Sch. Sci., Kobe Univ., Nada, Kobe 657-8501, Japan

Purpose

Olfactory sensory system has widely been developed in animals to detect environmental volatile chemicals. In ants as a social insect, their body surfaces are coved with nest-specific multi-components' odors and a particular type of chemosensory sensillum is used for nestmate-and nonnestmate discrimination. With this sensillum, they exhibit aggressive behavior toward non-nestmates (strangers) but not towards nestmates (familiar workers). This implies that the ant sensillum can sensitively detect newly coming odors. Learning from the ant sensillum, we could find new technology for sensing of environmental volatile, which can alarm for unusual changes of environment.

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Dr. Mamiko Ozaki
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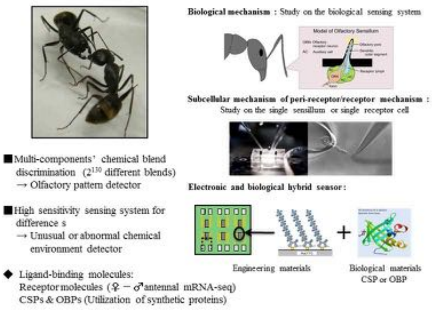
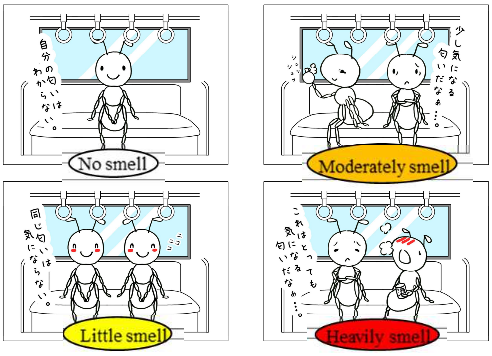
Research Background

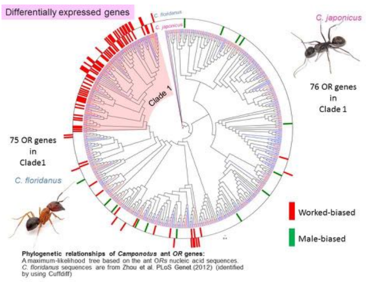
Our proposal for neo-biomimetic engineering of chemical sensing system

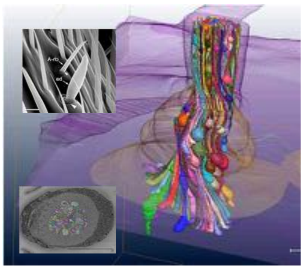


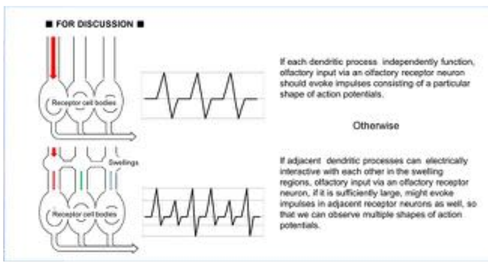
For realizing differential detection of odor in your experiences



Research Details







Summary

It has been reported that in the Japanese carpenter *ant,Camponotus japonicus*, workers discriminate between nestmates and non-nestmates by the sensilla basiconica on the antennae. We indicated that this type of sensilla house 130 olfactory receptor neurons (ORNs) possessing >100 olfactory receptor molecules, respectively. Here we observed ultrastructure of the sensilla basiconica using serial block face scanning electron microscope (SBF-SEM) and constructed its 3D model showing the particular shape like a twisted thick rope of ORNs. Dendritic processes of those over hundred ORNs have no branches but characteristic swellings (1-7 swellings/dendritic process). In this swelling region, cell membranes of ORNs are closely adjacent with complicated borders. We supposed to exist some interaction among these ORNs at such a swelling region. If it happens, it may affect the functional mechanism of the sensilla basiconica as a sensory unit to detect difference between odors of self and others.

～Development of Functional Material「SLUG」 Artificially Mimicking Biological Secretion System

Purpose

In this study, we report novel organogels named ナメクジ:SLUGs (Self-lubricating organogels), which are capable of spontaneously releasing liquids from inner gel matrices to their outer surfaces when triggered by a change in the surrounding conditions (*e.g.* temperature). Utilizing this phenomenon known as syneresis, novel materials can be prepared which possess excellent surface functionalities, including: 1) sustained anti-sticking properties against several viscous emulsions (mayonnaise, honey, ketchup, liquid glue, and worcester sauce) and their dry solidifications; 2) spontaneous formation/regeneration of superhydrophobicity; and 3) thermo-responsive anti-icing properties.

Contact Persons
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Dr. Chihiro Urata and Dr. Atsushi Hozumi
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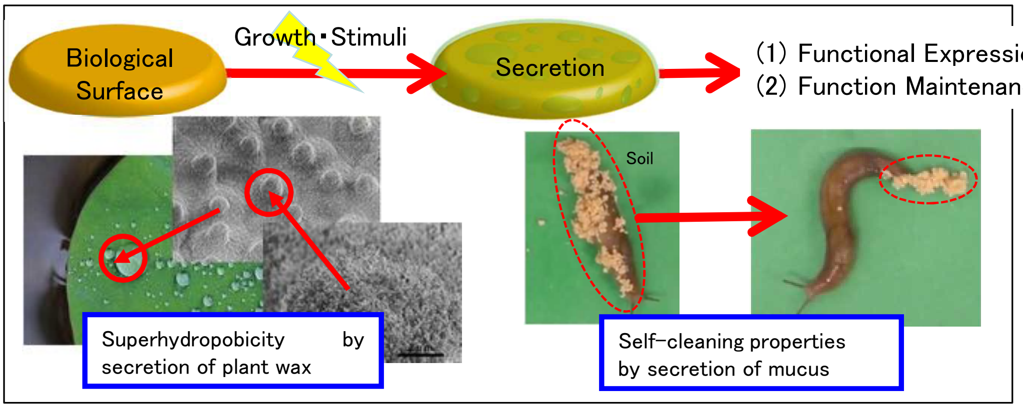
These organogels possess autonomic/thermo-responsive liquid-leaching functions that are quite different from conventional materials prepared using post-treatments such as SLIPSs and swollen gels(*J. Mater. Chem. A* **2015**, *3*, 12626.)。



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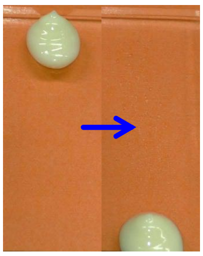
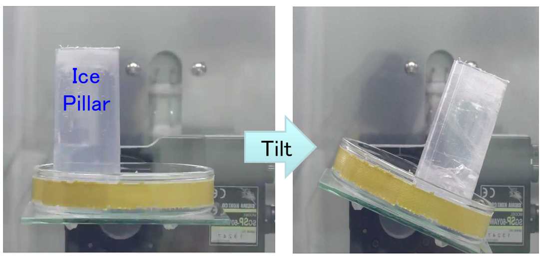
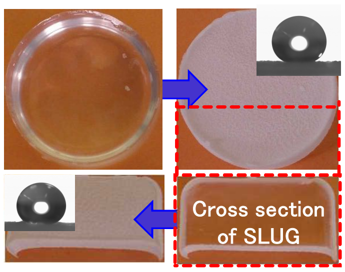


Sliding of mayonnaise



Sliding of ice pillar



Superhydrophobic and self-repairing properties

Summary

Self-lubricating organogels (SLUGs) are successfully prepared via a simple crosslinking reaction of PDMS in the presence of several organic liquids. Due to the syneresis of organogels, a liquid layer is continuously formed on the topmost SLUG surfaces under appropriate conditions. The resulting surfaces show multi-liquid repellency, regenerative superhydrophobicity, and thermo-sensitive anti-icing properties.

Engineering Neo-Biomimetics

平成24年度科学研究費補助金 新学術領域研究(研究領域提案型)

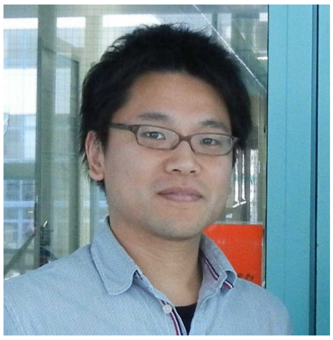
生物多様性を規範とする革新的材料技術

Innovative Materials Engineering Based on Biological Diversity

～Surface design for improving the heat transfer～

Purpose

To release heat generated from electric devices plays an important role in working properly. Two approaches for enhancement of releasing the heat is to activate the mobility of phonon, related to thermal conductivity, and to control electromagnetic waves, related to heat radiation, on the material surfaces. In this work, we attempted to construct surface design for improving the heat transfer.

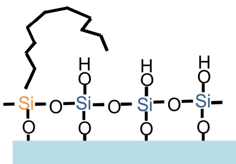


Contact Person
Nagoya Institute of Technology
Dr. Hirotaka Maeda
maeda.hirotaka@nitech.ac.jp

・Enhancement of mean free path of phonon

・Consumption of heat

→ Utilizing motion of molecular chains for increasing the thermal diffusivity

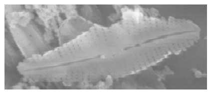


Saharan silver ants

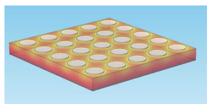
・Excellent reflectivity and emissivity by a dense array of triangular hairs

Diatom

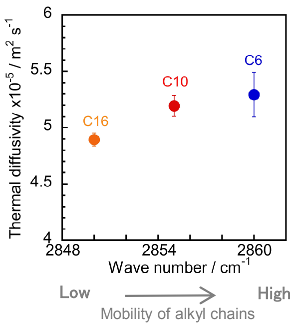
・Light focusing effect due to surface geometry

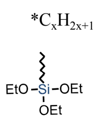


→ Utilizing surface structure for controlling electromagnetic waves

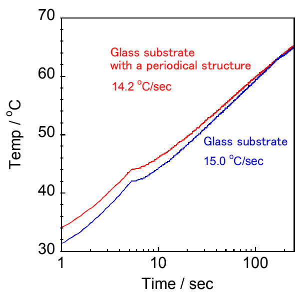


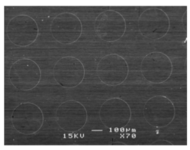
Research Details





Effect of molecular chain lengths on thermal diffusivity.





Temperature change on graphic cards in computer.

Summary

The motion of molecular chains at the material surface influenced the thermal diffusivity.
The heat release rate on graphic cards was enhanced by the periodical structure on the surface.

～Flexible wing-and body-based strategies for bio-inspired flight system: aerodynamics and flight stability

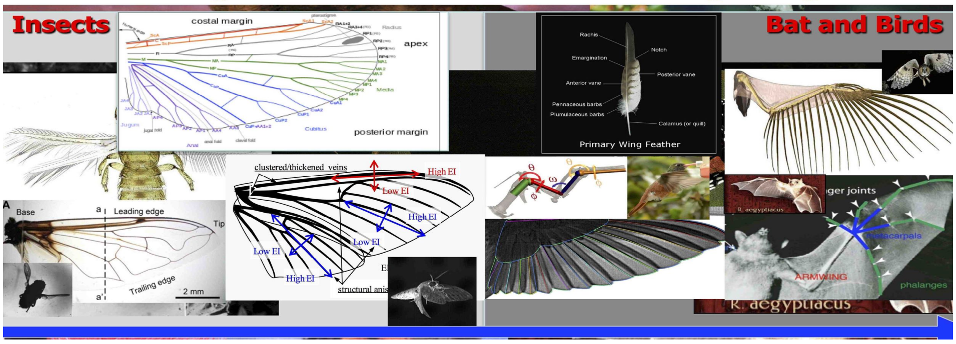
Purpose

Flying animals are capable of sophisticated, aerodynamic force production and precise, agile maneuvering, which are achieved through more straight-forward sensorimotor pathways to modulate power output from the steering muscles to the wing. Flight control requires complicated motor systems in response to multimodal sensory inputs and the coordination of multiple muscles across the body. Flexible structures of wing and body in flying animals have been pointed out to hold great potentials in enhancing aerodynamic performance and steering maneuverability in flapping-wing flight. The flexible strategies in biological flights and bio-inspired flight system associated with micro air vehicles very likely play an important role in the control and sensorimotor of flapping-wing flight (Proc B 279, 2012).

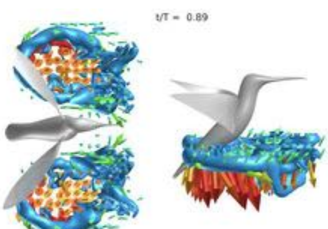
Contact
Chiba University
Prof. Hao Liu
hliu@faculty.chiba-u.jp

In this study we aim at unveiling the novel mechanisms in flexible wing-and body-based strategies on how the flexible wing and the body flexion work aerodynamically in terms of aerodynamic force-production and dynamic flight stability as well as application in designing bio-inspired flapping wings for micro air vehicles.

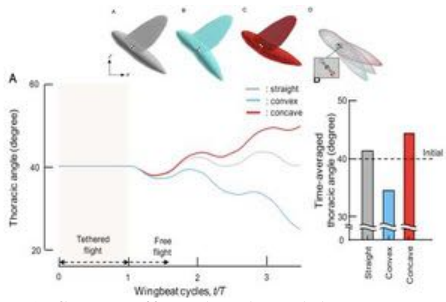
Scaling Law and Rules for Flexible Wing Design



Research Details



Flexible wings enhance vortex and force generation in hummingbird hovering.



Body flexion affects hawkmoth hovering: Time varying and averaged thoracic angles.

Summary

Wing flexibility in hovering flights of hawkmoth and hummingbird can create larger aerodynamic forces and achieve better aerodynamic efficiencies. Bio-inspired wing kinematics and deformations are more important rather than wing structures (vein, membrane, musculature).

平成24年度科学研究費補助金 新学術領域研究(研究領域提案型)

Engineering Neo-Biomimetics

生物多様性を規範とする革新的材料技術

Innovative Materials Engineering Based on Biological Diversity

Construction of a database supporting development of biomimetic products

Purpose

TRIZ method is useful to solve problems in sustainable engineering. This problem solving method was discovered that the evolution of technical ideas followed predictable patterns. The tools used to overcome technological contradictions are called "principles", and 40 principles is utilize in problem solving. In this presentation, Construction of a database for the application of TRIZ for nature material design was described. From a biomimetic aspect, 40 principles would be useful for design of sustainable materials.

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Process for biomimetic products by International Organization for Standardization

Problem Formulation → Problem Reframing → Biological Solution Search → Defining Solution Search → Extract Principle → Problem Application

To solve a contradiction

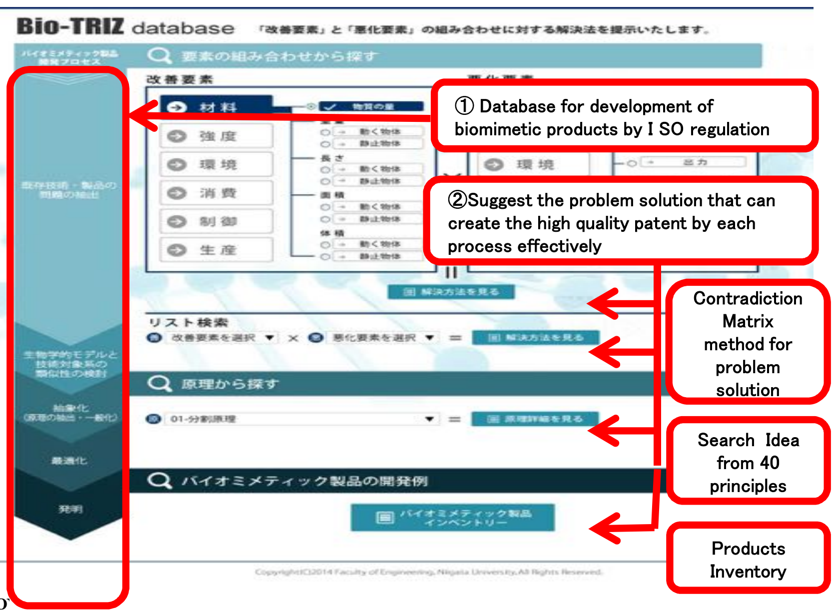
Database of biomimetic solutions by Nature

BioTRIZ

Technical committees 266 - Biomimetics-

Research Details

We have introduced a problem solution technique called bioTRIZ and constructed the database which could develop a biomimetic product of the ISO.



Summary

We simplified the new database that an engineer has only put a technical problem in a technical contradiction matrix and it proposes new engineering ideas from nature to solve the problem.

Biomimetics R&D and Standardization

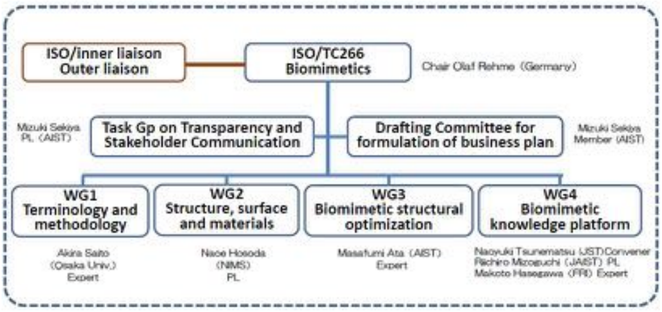
●Introduction

Standard development for biomimetics has started on October 2012 within ISO and new ISO standards will be published as early as the end of 2015. The first two ISO standards are on "definitions for biomimetics (WG1)" and "biomimetic optimization of industrial products (WG3)" which are closely related to industry. Launch of a new working group on "sustainability and biomimetics" is scheduled for the next TC266 Biomimetics meeting which will be held on October 2015. This poster provides a brief overview of current activities in TC266 Biomimetics and challenges for the future.

Terpsiphone atrocaudata: Male black paradise flycatcher has bright blue eye ring and beak. The color is created by biological nanostructures. They build a nest by knitting up moss, cypress skin and spider silk.

●ISO/TC266 Biomimetics, activities now and the future

ISO/TC266 Biomimetics《Structure》



As of March 2015

《Participating countries》

P member (voting member)	O member (non-voting member)
China (SAC)	Argentina (IRAM)
Czech (UNMZ)	Denmark (DS)
France (AFNOR)	Finland (SFS)
Germany (DIN) - Secretariat	India (BIS)
Japan (JISC)	Iran (ISIRI)
South Korea (KATS)	Kazakhstan (KAZMEMST)
Belgium (NBN)	Malaysia (DSM)
The Netherlands (NEN)	Poland (PKN)
UK (BSI)	Serbia (ISS)
Israel (SII)	Sweden (SIS)
Canada (CSA) - since the 4th meeting	Switzerland (SNV)
	Thailand (TISI)
	US (ANSI) - withdraw after the 4th meeting

As of September 2015

Japan's ideas for future biomimetics standardization

▷Use international standards to foster innovation, not the other way around.
<< In emerging and interdisciplinary area, Technical Specification (TS) is preferable as it allows stakeholders to harmonize opinion.

▷Support "Transparency and Stakeholder Communication"
<< Make "better standards" at the initiative of Japan.

▷Develop a strategic approach to "sustainability issue" and appoint the right person.
<< Avoid implementation of rash and indiscreet management.

▷Standards development requires reflection of industry needs.
<< ISO standards rely on the voluntary activities based on industry and other stakeholders needs. We expect more participants for better ISO standards.

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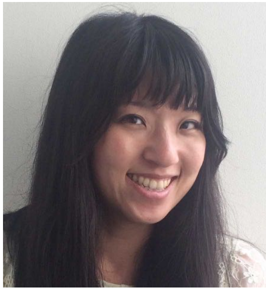
～Water transportation system of sponges～

●Purpose

- Construction of robust and extensible network is demanded in various field such as traffic, telecommunication and water distributing pipe network.
- Sponges are sessile aquatic animals. Sponges continuously flow ambient water through a vast canal system inside their body, and filter out and feed suspended organic particles. As sponges have no specialized organ such as digestive tract, they not only feed, but also breathe and breed by water flowing through the canal system. Their dependence on the canal system suggests that the sponge canal system should be optimized for efficient water transportation, which would potentially serve as a model system for designing a water transportation system with high energy efficiency.



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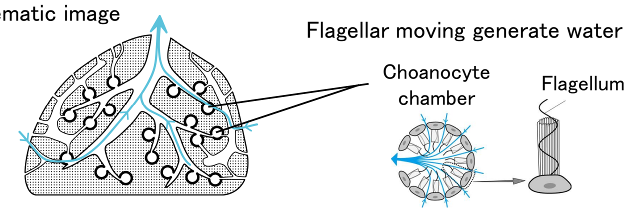
▲ Sea sponge

Schematic image

Flagellar moving generate water flow



NETWORK STRUCTURE

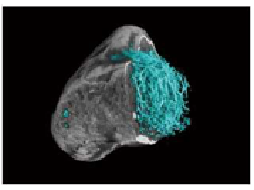
FLOW GENERATOR

Keywords
・Robustness
・Network

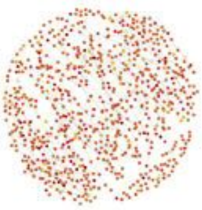
Robust and extensible network system inspired by sponge

●Research Details

・We created a computer program to extract network structure from CT images.



▲ 3D image of sponge canal system.



▲ Extracted network structure

・Fundamental information on flagellar movement was obtained through high-speed recording.

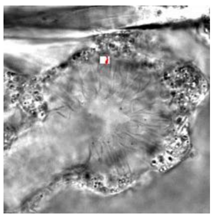
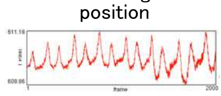


Image banalization of flagellar basement region

Time course change of center position



Average frequency: ca. 20 per sec

●Summary

We demonstrated some key principles of the sponge water transportation system from two different perspectives, canal network structure and flagellar beating. Further studies are needed to elucidate the functional mechanism of sponge canal network system.

Pressure-Sensitive Adhesive Powder

Purpose

Pressure-sensitive adhesives (PSAs) are viscoelastic polymer materials that instantly adhere to solid surfaces via van der Waals forces upon application of a light contact pressure. PSAs are commonly applied in the form of a thin layer on a substrate or spraying droplets. Although the PSAs are useful functional materials, their sticky nature often makes them intractable, and there is a strong demand for development of easy handling PSAs. Here, we introduce a new concept for synthesizing PSA powder based on liquid marble technology. PSA powder consists of particles with a soft adhesive polymer core and a hard nanoparticle shell morphology, and shows no adhesion in its original form and flows like a powder. Only after application of shear stress, it then shows its adhesive nature. Adhesion is induced by rupture of the nanoparticle coating of the powder and outflow of the inner soft polymer.

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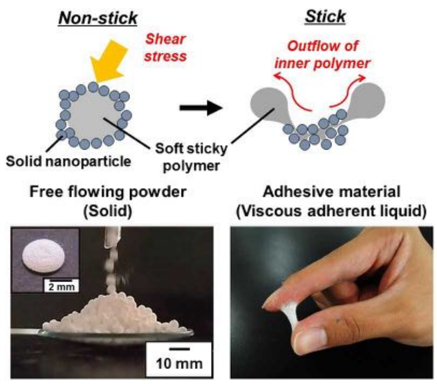
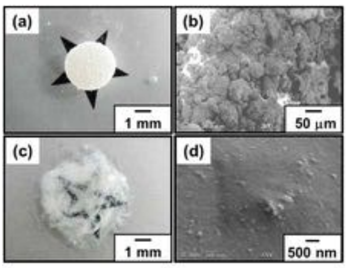
Pressure-sensitive adhesive (PSA) powder consisting of particles with an adhesive polymer core and a hard nanoparticle shell morphology have been synthesized based on liquid marble technology. The PSA shows no adhesion in its original form, and shows its adhesive nature only after application of shear stress.

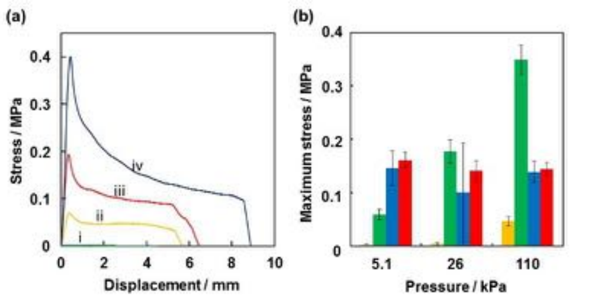


Schematic representation of PSA powder consisting of particles with a soft sticky polymer core and a solid nanoparticle shell morphology. After application of shear stress, adhesive nature appeared because of outflow of the inner soft polymer. Optical photographs of such PSA materials are also shown. The PSA shows no adhesion in its original form and flows freely like a powder. (Inset shows single PSA particle.) Only after application of shear stress, it acts as an adhesive.

Research Details



(a,c) Digital photographs and (b,d) SEM images of a particle with a soft adhesive PBA core and a hard $CaCO_3$ nanoparticle shell morphology (a,b) before and (c,d) after application of shear stress.



(a) Stress-displacement tack curves obtained for PSA liquid marble: (i) before and (ii-iv) after application of shear stress. Pressure applied to PSA liquid marbles: (i, ii) 5.1, (iii) 26 and (iv) 110 kPa. (b) Relationship between pressure applied to PSA materials and maximum stress in tack measurement. Samples: Liquid marble PSA (yellow bar) before and (green bar) after application of shear stress, (blue bar) PBA latex film with a thickness of 45 μm and (red bar) commercially available PSA tape (Scotch® Magic™ Tape 810)

Summary

The PSA shows no adhesive character in its initial form and flows like a powder. After application of shear stress, the adhesive nature appeared induced by rupture of the $CaCO_3$ nanoparticle coating and outflow of soft polymer. The PSA powder should be particularly useful in bonding in confined and intricate spaces (e.g. fastening screw and cracking of walls) where sticky polymeric materials are difficult to apply due to their high viscosity.

The NanoSuit® method to observe the living mammalian tissue and cell

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Ⅰ Abstract

A field emission scanning electron microscopy (FE-SEM) has been made remarkable progress, and has become an essential tool for observing the fine structure of biological materials. However, various complex procedures are necessary for the observation, therefore, preclude the observation of living organisms to date. We previously found the simple surface modification (the 'NanoSuit®' method) can render multicellular organisms strongly tolerant to high vacuum, resulting in a successful observation of living organisms by FE-SEM (Takaku *et al.*, 2013; Suzuki *et al.*, 2013; Ohta *et al.*, 2014; Takaku et al., 2015). In brief, animals, which collapsed under high vacuum (10^{-3}-10^{-7} Pa), can survive and move continuously in FE-SEM if they possess their natural extracellular surface layer (or are covered with an artificial solution layer made from a dilute amphiphilic compounds such as polysorbitan monolaurate) and are irradiated by electron beam or plasma to enhance the polymer formation covering the whole animal body with NanoSuit. We recently succeeded to apply this technique to the living mammalian tissues and cells, and found that the fine structure of the living specimen surface is completely different from that of traditionally fixed sample. The observed specimens were able to re-culture in a culturing medium, i.e. these specimens seem to reflect the real living structures. The specimens including the human body are observable with a real structure in a short time without any additional procedures when we use the NanoSuit method. These findings should encourage the development of more sophisticated observation methods for studying living organisms in a FE-SEM.

Ⅱ Introduction

We can observe living and moving specimens with FE-SEM !

(1) Various complex procedures with fixing tissues have precluded the real fine structure of organisms by a field emission scanning electron microscope (FE-SEM).
(2) We have reported a new method to observe living organisms; their surfaces are covered with a thin-layer of irradiated membrane (the NanoSuit® method: Takaku et al, 2013; Suzuki et al, 2013; Ohta et al, 2014, Takaku et al, 2015) .
(3) Our method permits the use of a high vacuum(10^{-3}〜10^{-7}Pa) and achieves fine structural observations on live specimens.
(4) Here we present new results observed by the NanoSuit method.

Basic concept of NanoSuit

After modification of materials on the surface of organisms by exposure to electron beam or plasma ionization, the treated animals showed spontaneous movements *in high vacuo* (10^{-3}-10^{-7} Pa).

untreated

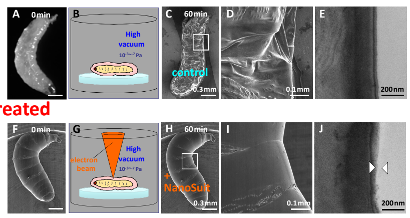


Fig. 1. (*A-D*) Prior to SEM observation, a living larva (light micrograph in A) was placed in the observation chamber without electron beam irradiation for 60 min. The specimen collapsed completely when subsequently observed by SEM. (F-I) A different *Drosophila* larva was exposed to high vacuum with electron beam irradiation for 60 min. Each small white square in *C, H,* is shown magnified (*D, I*, respectively). (*E, J*) TEM images are shown of vertical sections through the surface of each animal. The layer between the arrowheads in *J* indicates the limits of the newly formed outer membrane, not present in *E*. An outer layer covering the animal represents extra cellular substances (ECS) in *B, G*.

untreated

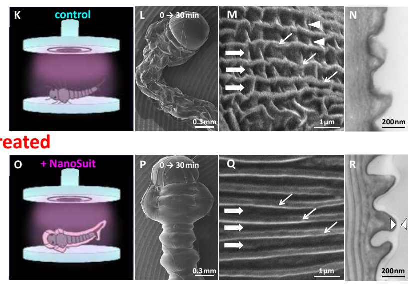
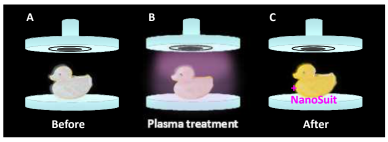


Fig. 2. (*K-M*) A living larval mosquito *Culex pipiens molestus* (which has no natural ECS layer) treated by plasma irradiation for 3 min and observed by SEM for 30 min. (*O-Q*) Images of the larval mosquito, following early electron irradiation, protected by plasma-irradiated Tween 20. (*M, Q*) High magnification image of the body surface in each animal. In *N* and *R*, TEM images of the surfaces of each animal are shown. Layers between the arrowheads indicate the newly formed NanoSuit. An outer layer covering the animal an artificial extra cellular substance (Tween 20) in *O*.

Ⅲ Experimental procedures

Specimens: excised tissues from human stomach. Melanoma cell. Mouse liver. *Drosophila* and *Hydra*.

Treatment: Specimens were dipped into the SSE solution for 1 min and irradiated by plasma to construct the NanoSuit.

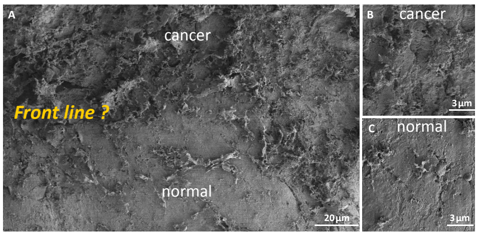


FE-SEM observation: All the specimens tolerated the high vacuum well, exhibiting fine structures (Max. x 100,000).

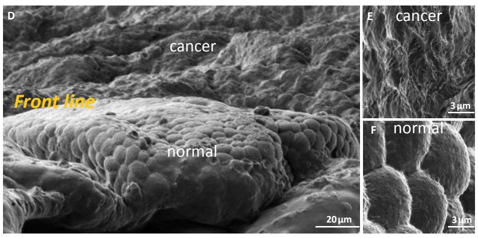
Ⅳ Results

① Stomach cancer (human)

Conventional image



NanoSuit image



NanoSuit + HE image

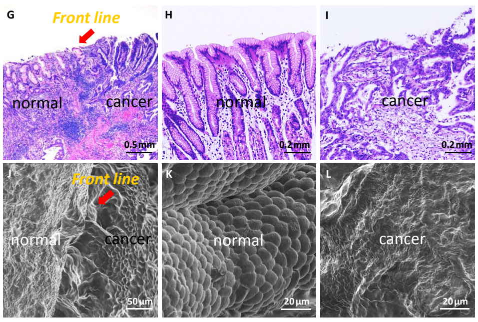


Fig. 3. In the conventional view, the position of the front line between normal and cancer tissues was indistinct because the specimen collapsed (A-C). In contrast, NanoSuit image clearly showed the line (D-F), suggesting that new method holds the surface faithfully intact. The combination NanoSuit method with HE staining directly revealed the area of cancer (G-L).

② Cancer cell (melanoma cell)

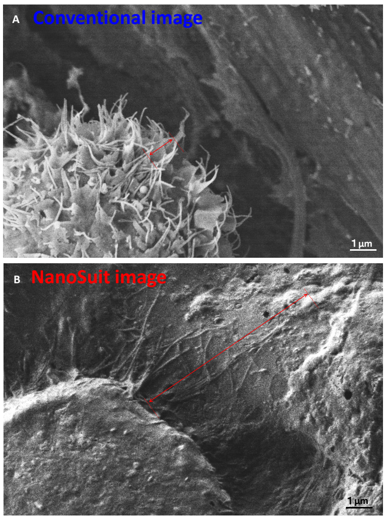


Fig. 4. Conventional method resulted in disruption of the surface (A), whereas NanoSuit technique maintained the nano fiber structures (B).

③ Nano fiber structures in developmental and regenerated tissue

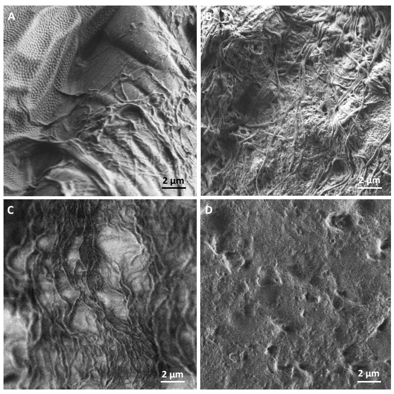


Fig. 5. Nano fiber structures were detected in developmental process of *Drosophila* eye (A) and *Hydra* regeneration (B). The fibers were also observed in the liver regeneration in mouse (C). However, it was not distinct on the cross section of non-regererative tissue (D).

Ⅴ Conclusion

We have succeeded to apply NanoSuit technique to the living mammalian tissues and cells, and found that the fine structure of the living specimen surface is completely different from that of traditionally fixed sample. Furthermore, the method is simpler and less time-consuming than conventional SEM procedures and greatly facilitates the imaging of biological samples hitherto considered unsuitable for the high vacuum conditions of the conventional SEM.

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Estimation of Salient Region Based on Support Vector Machine for Scanning Electron Microphotographs

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This paper presents an estimation method of salient region that is related to a function of an organism based on Support Vector Machine (SVM) for Scanning Electron Microphotographs (SEM images). Overview of the proposed method is shown in the figure (see below). First, the proposed method calculates visual feature vectors of SEM images in the training dataset and obtains an SVM hyperplane which decides whether their images are related to a focused function from their feature vectors. Next, we clip local blocks from a test image and obtain their visual feature vectors. For each local block of the test image, the distance between its visual feature vector and the SVM hyperplane is calculated. Since this distance represents "the probability of membership in a particular class, i.e., the probability having the focused function", the estimation of the salient region of the test SEM image becomes feasible by using it. Experimental results obtained by applying the proposed method to SEM images show its effectiveness.

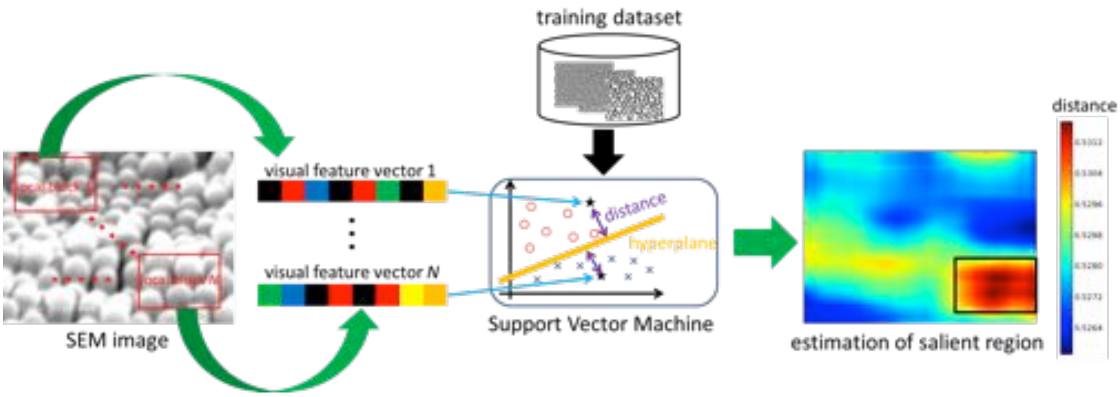

Figure: Overview of the proposed method.

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