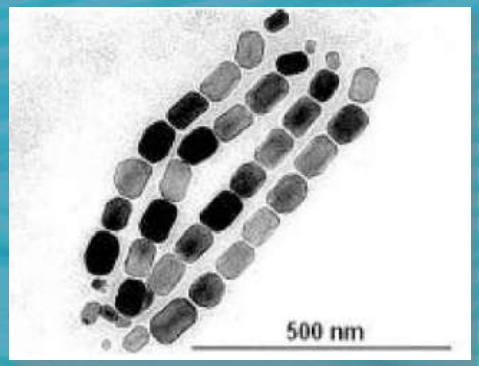
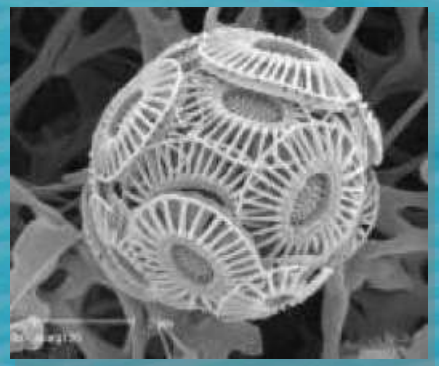




"Producing each of its creations ... nature intermingled the **harmony of beauty and** the harmony of **expediency** and shaped it into the unique form which is perfect from the point of view of an engineer."

(M. Tupolev)

Nanobioconvergence

Ille C. Gebeshuber

IMEN, Universiti Kebangsaan Malaysia
IAP, Vienna University of Technology, Austria
AC^{2}T Austrian Center of Competence for Tribology

Lecture given on 30.01.2013,
at the online International Embryo Physics Course held in Second Life®

Outline

- Definition
- Examples from nature and technology
- Governance, Risks and Societal Implications
- Conclusions

Gebeshuber I.C., Macqueen M.O. and Majlis B.Y. (in press) *Nanobioconvergence. In: Nanotechnology in the edge of convergence*, Kulshreshtha A.P. (Ed.)

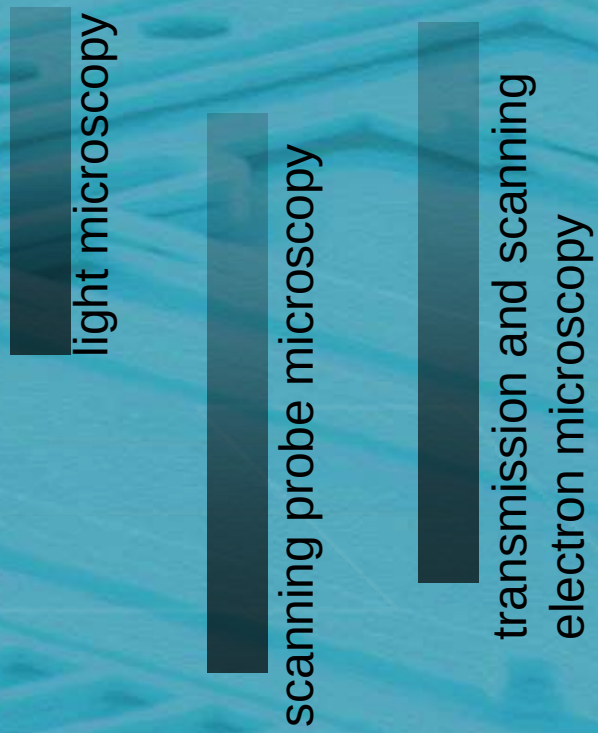
Definition

Nanobioconvergence denotes the merging of life sciences, especially biology and biotechnology, with nanoscience and nanotechnology, focusing on the technical output from the connections of these particular fields as well as on the unified opportunities and challenges they present to human nature and our values.

Gebeshuber I.C., Gruber P. and Drack M. (2010) *Nanobioconvergence*. In: Encyclopedia of Nanoscience and Society, Vol. 2, (Eds. Guston D. and Golson J.G.), 1st edition (July 14, 2010), Sage Publications, CA, USA, 454-456.

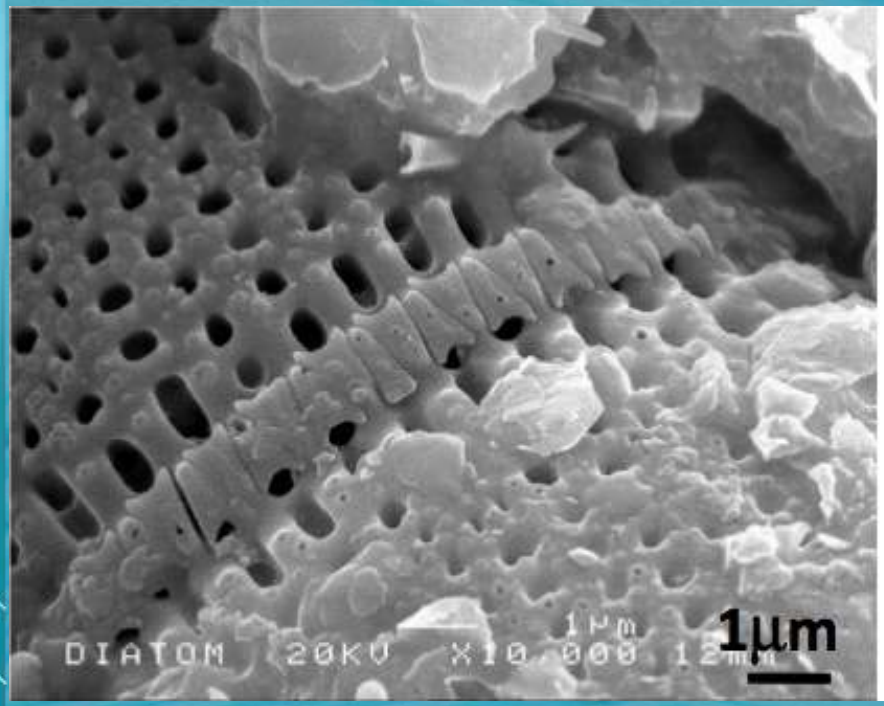
From the Macro- to the Nanoscale

10^{0}m	woman
10^{-1}m	small animal
10^{-2}m	lady bug
10^{-3}m	flea
10^{-4}m	amoeba
10^{-5}m	red blood cell
10^{-6}m	cholera bacterium
10^{-7}m	tobacco mosaic virus
10^{-8}m	large organic molecule
10^{-9}m	large molecule
10^{-10}m	atom
10^{-11}m	atom orbitals



Gebeshuber I.C., Drack M., Aumayr F., Winter HP. and Franek F. (2006) *Scanning Probe Microscopy: From living cells to the subatomic range*, In: Applied Scanning Probe Methods III, Springer, 27-53.

200 nm wide linking structures



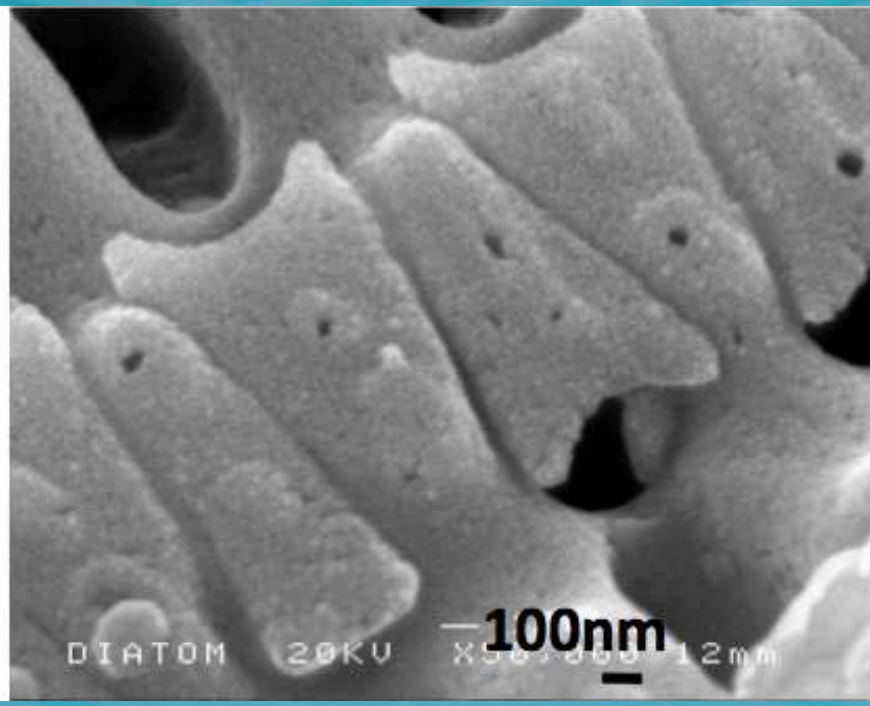
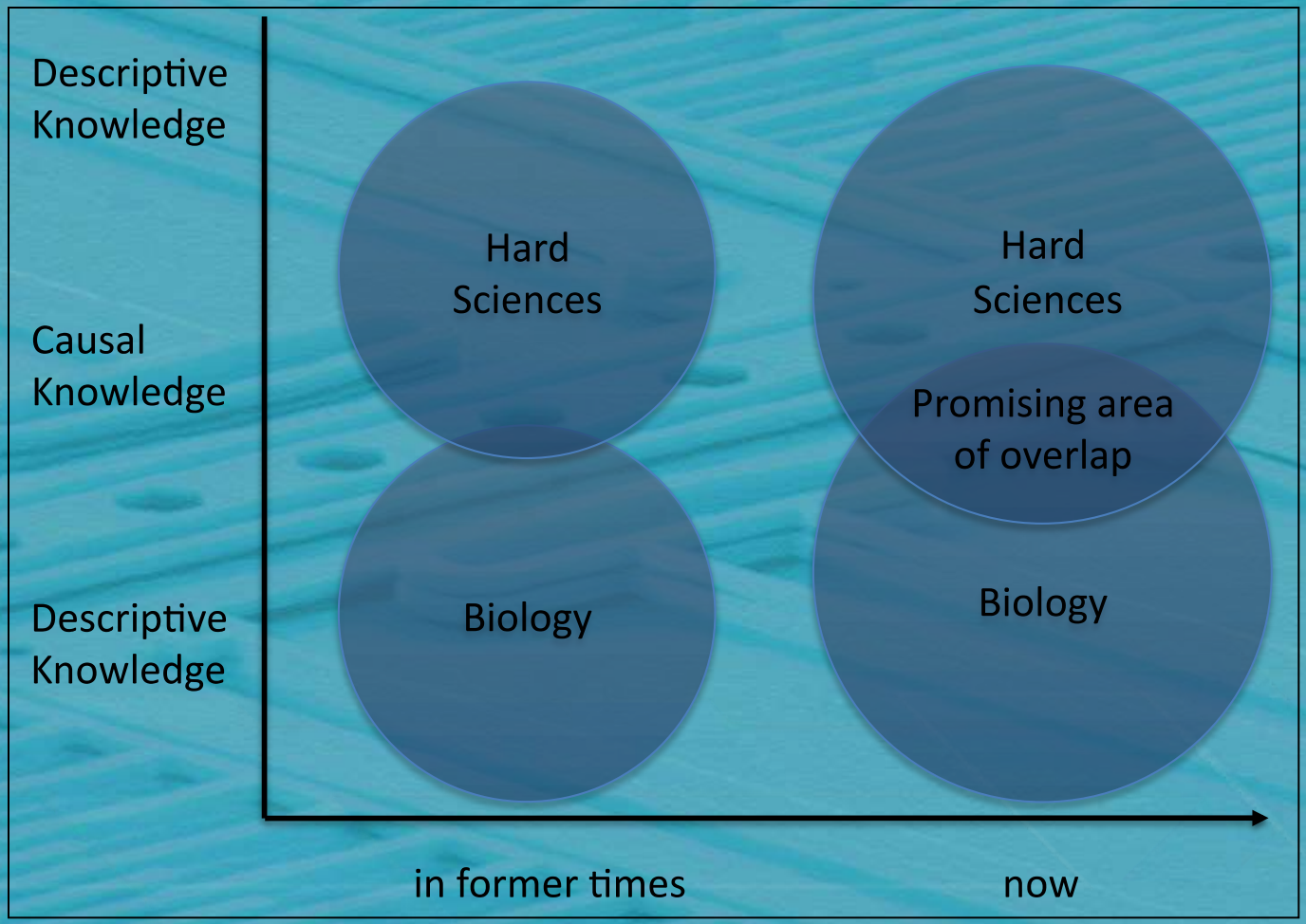


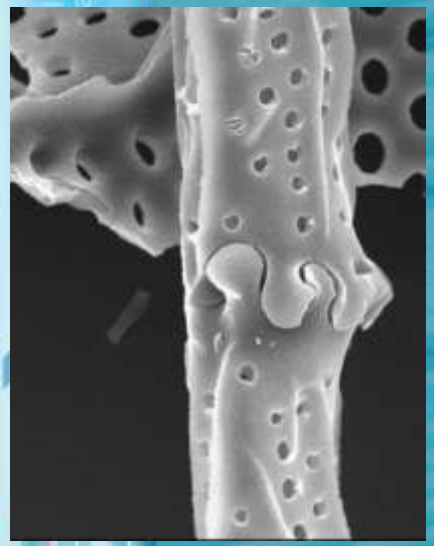
Image © Duncan Waddell, Queensland Art Gallery, Australia

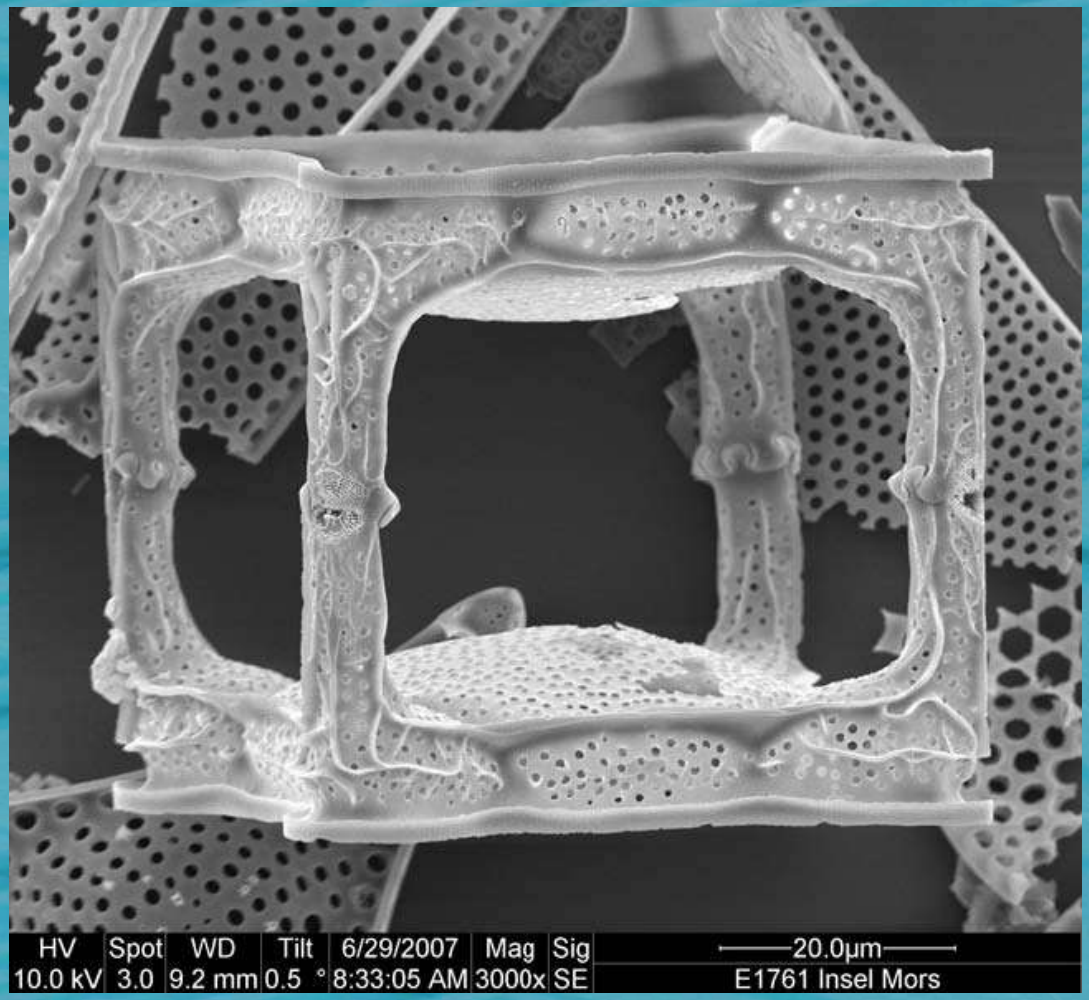
Gebeshuber I.C., Scherge M. and Drack M. (2008) *Tribology in Biology.* Tribolgy 2(4), 200-212.

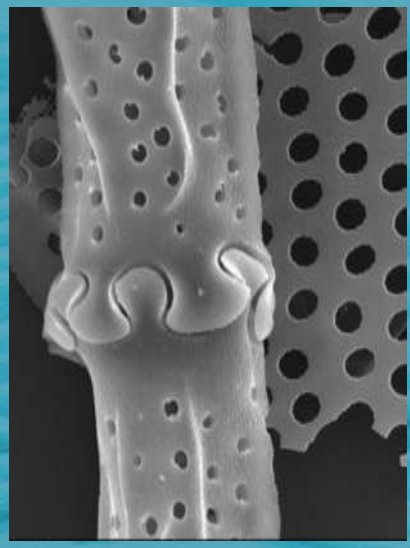
Hard Sciences meet Biology



Gebeshuber I.C., H. Stachelberger and B.Y. Majlis (2009) *Exploring the innovation potential of biomimetics for novel 3D micro- and nanoelectromechanical Systems (MEMS and NEMS)*. Proc. Sixth Plant Biomechanics Conference, November 16th - 21st, 2009, Cayenne, French Guyana, France, Ed. Bernard Thibaut, 374-381.







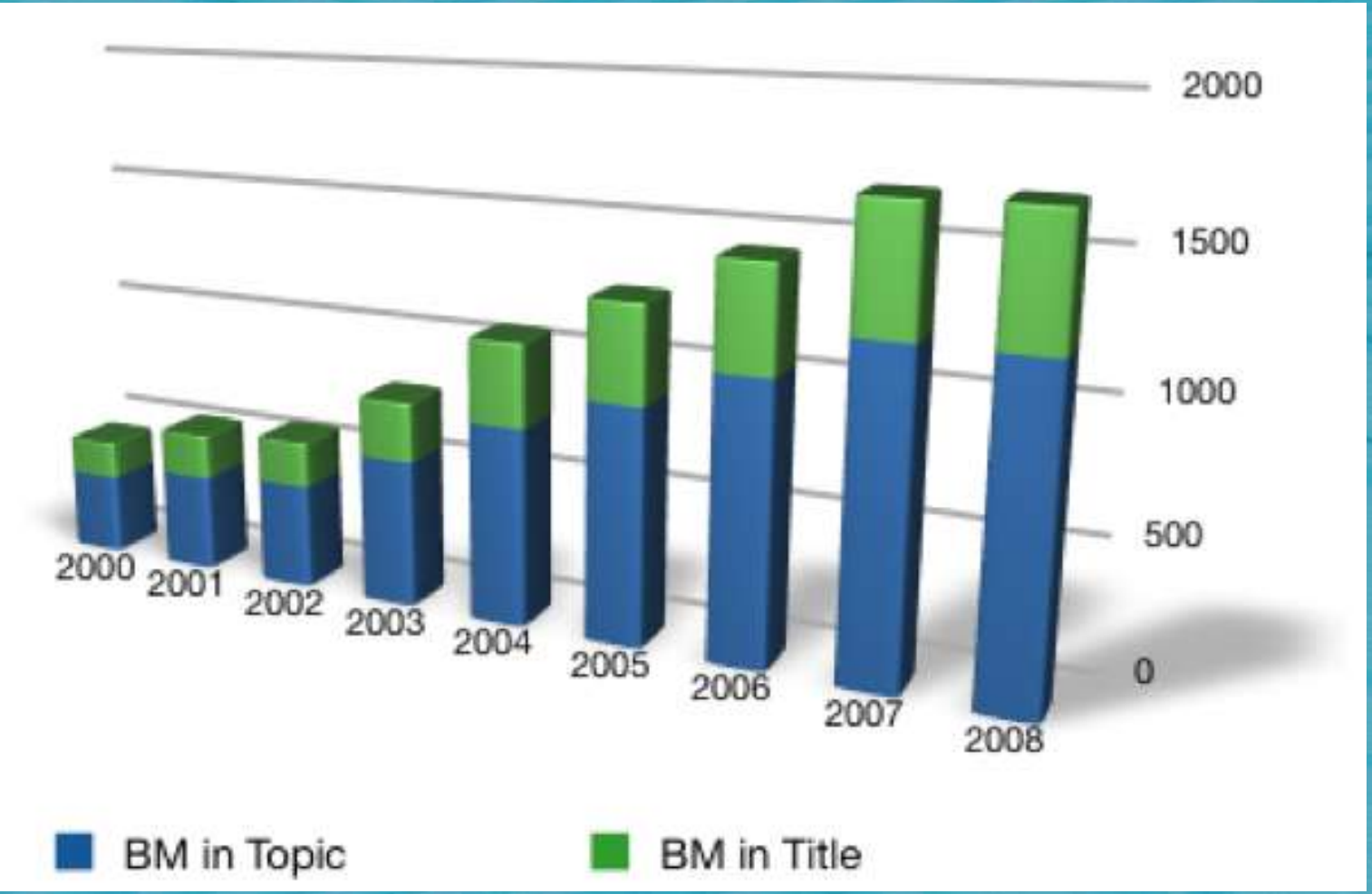
© Friedel Hinz, AWI Bremerhaven, Germany

Gebeshuber I.C. (2007) *Biotribology inspires new technologies.* Nano Today 2(5), 30-37.

Biomimetics is the abstraction of good design from nature.

Center for Biomimetics, UK

The Rise of Biomimetics



Gebeshuber I.C., Majlis B.Y. and Stachelberger H. (2009) *Tribology in Biology: Biomimetic studies across dimensions and across fields.* Int. J. Mech. Mat. Eng. 4(3), 321-327.

General Biomimetic Principles

Can be applied by engineers who are not at all involved in biology.

1. Integration instead of additive construction
2. Optimization of the whole instead of maximization of a single component feature
3. Multi-functionality instead of mono-functionality
4. Fine-tuning regarding the environment
5. Energy efficiency

Nachtigall W. (2009) *Vorbild Natur: Bionik-Design für funktionelles Gestalten.* Springer, Berlin.

General Biomimetic Principles

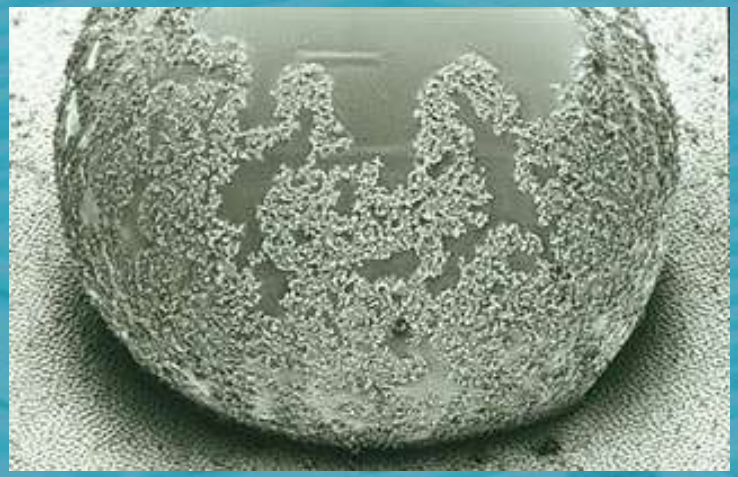
Can be applied by engineers who are not at all involved in biology.

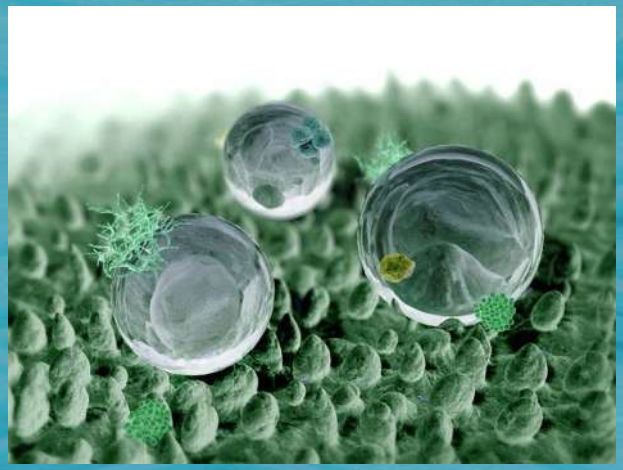
6. Direct and indirect usage of solar energy
7. Limitation in time instead of unnecessary durability
8. Full recycling instead of piling waste
9. Interconnectedness as opposed to linearity
10. Development via trial-and-error processes

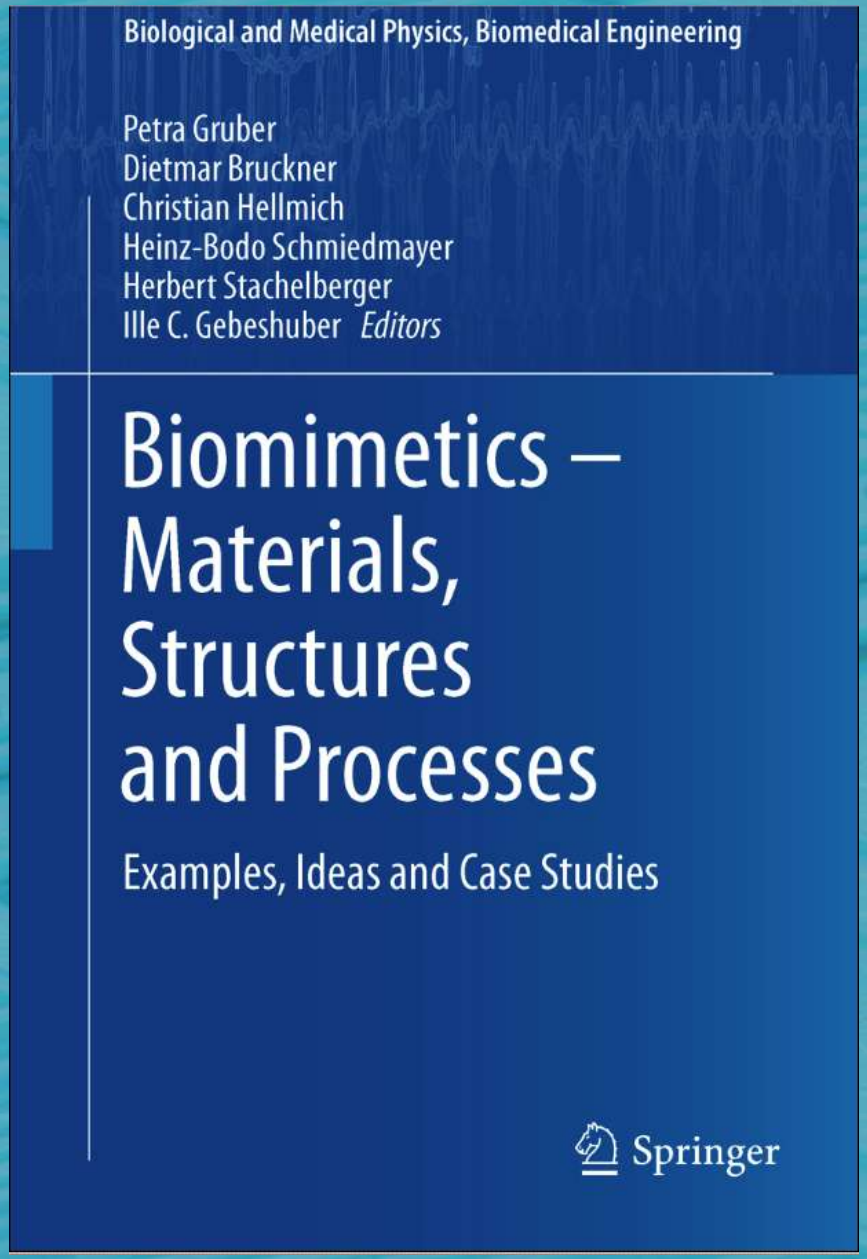
Nachtigall W. (2009) *Vorbild Natur: Bionik-Design für funktionelles Gestalten.* Springer, Berlin.

Biological Materials

- Tough materials
- Smart materials
- Adaptive materials
- Functional materials
- Materials with molecular precision
- Hierarchical materials
- Multiuse materials







Gruber P., Bruckner D., Hellmich C., Schmiedmayer H.-B., Stachelberger H. and Gebeshuber I.C. (Eds, 2011)
Biomimetics - Materials, Structures and Processes. Examples, Ideas and Case Studies, Springer.

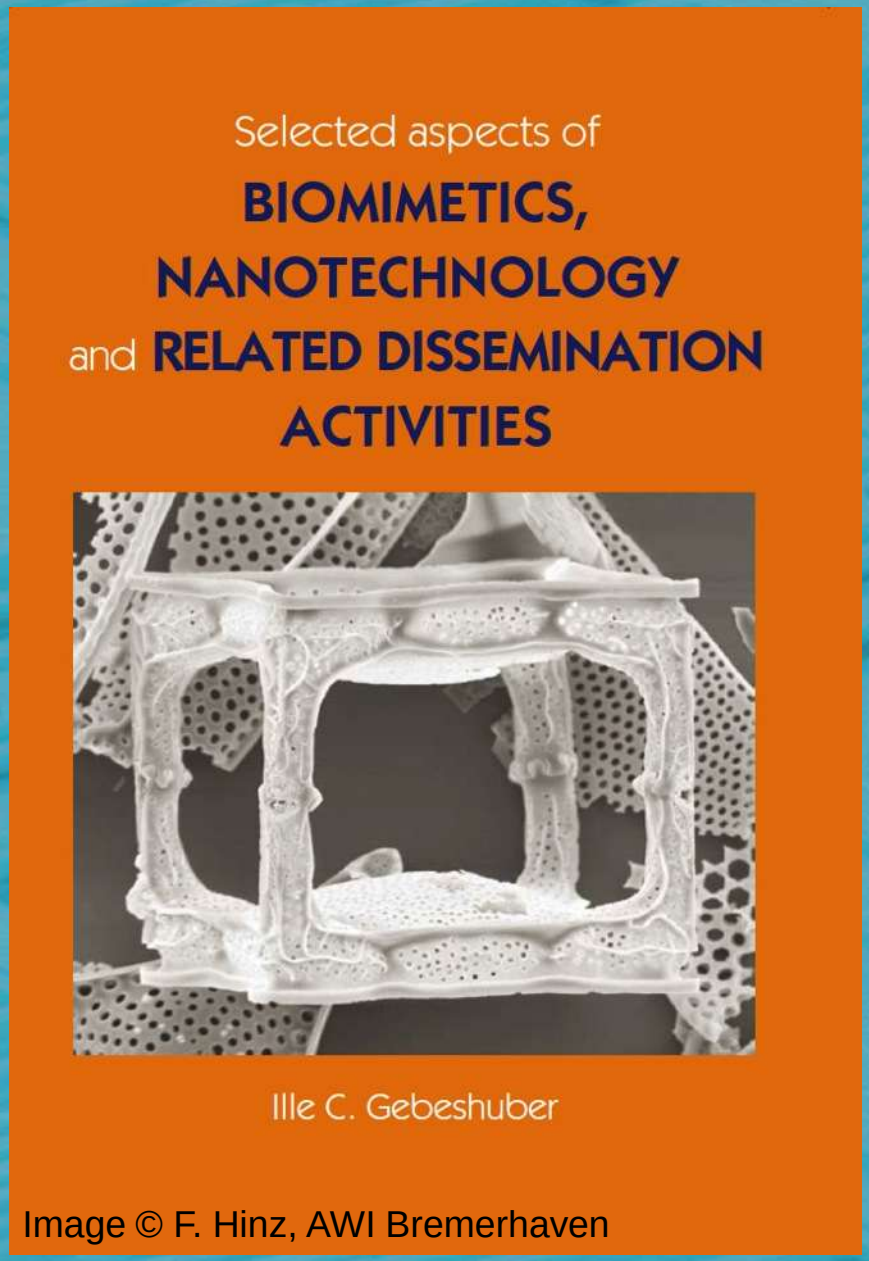


Image © F. Hinz, AWI Bremerhaven

Gebeshuber I.C. (2011) *Biomimetics and Nanotechnology*, UKM Press, Penerbit Universiti Kebangsaan Malaysia, Bangi, ISBN 978-967-412-004-7.

Molecular Motors

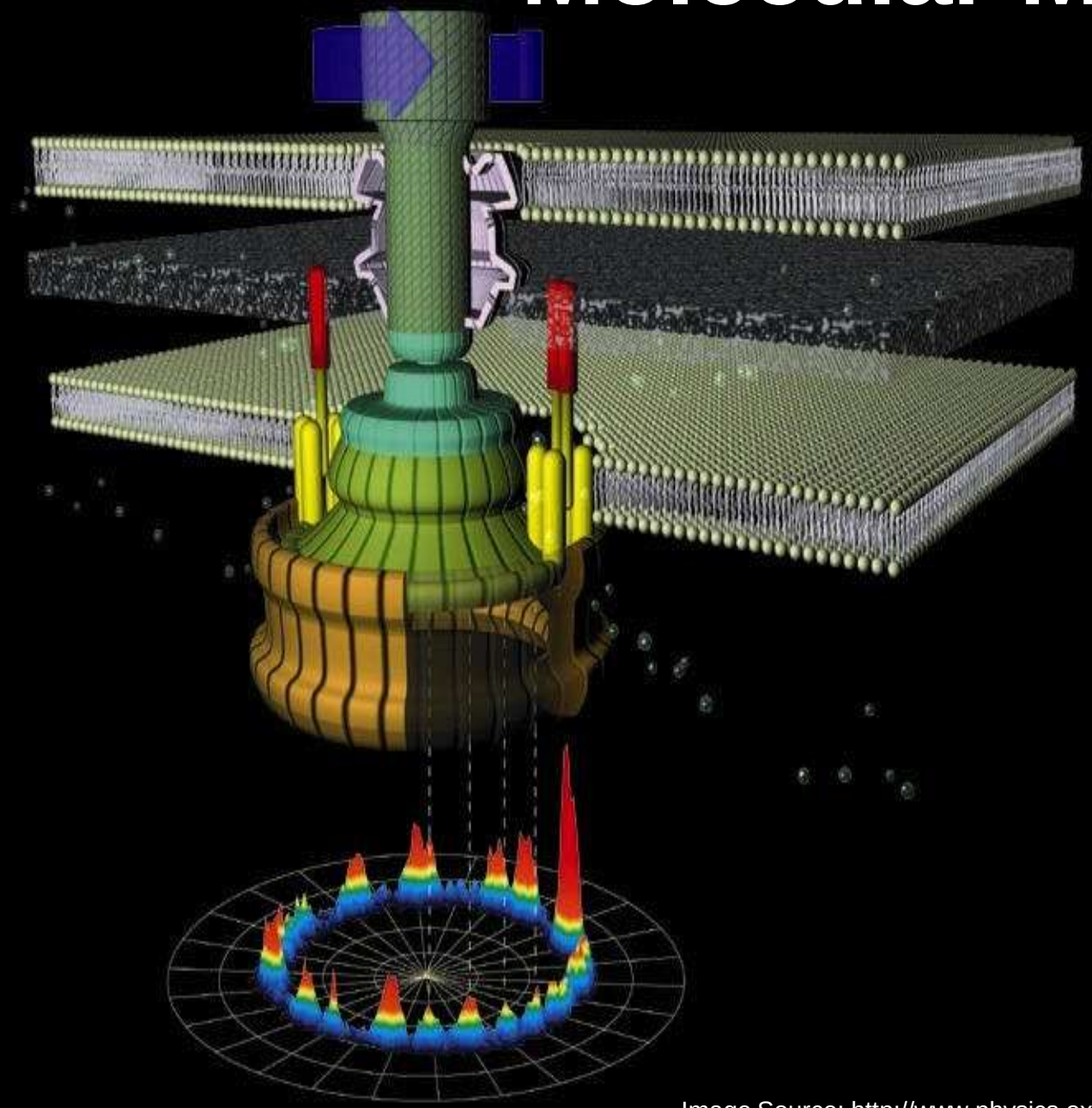
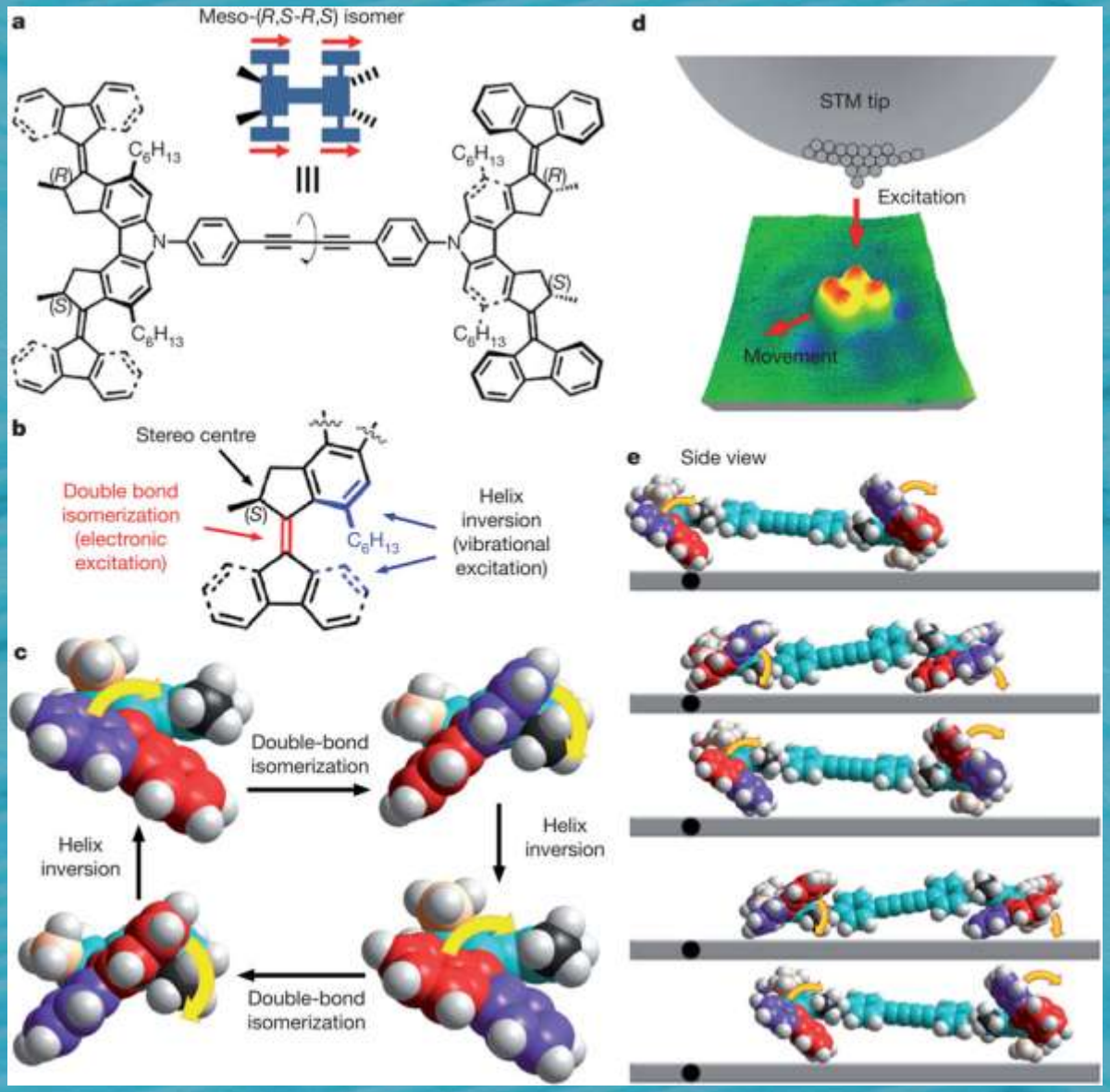


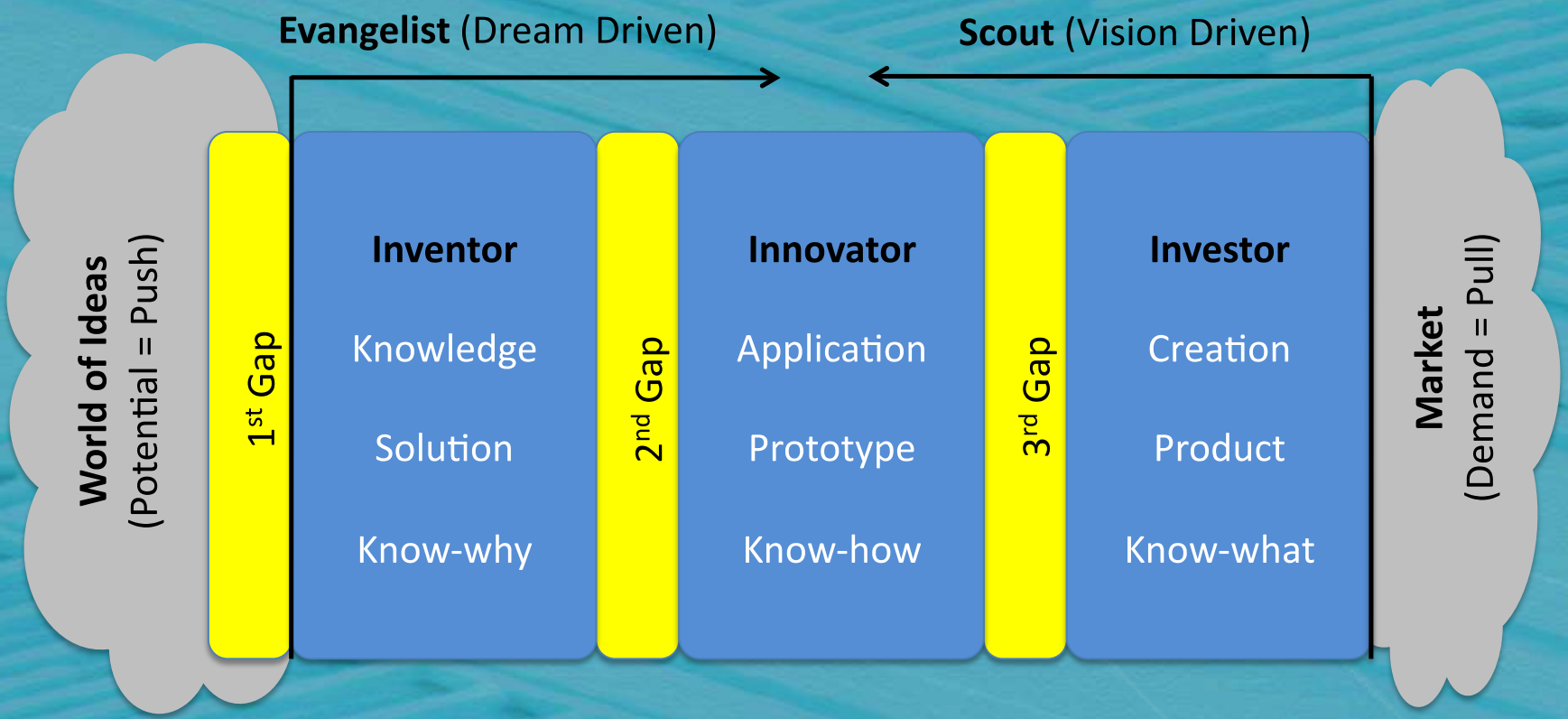
Image Source: http://www.physics.ox.ac.uk/berry/research/BFM/

Nanocar



Kudernac T., Ruangsupapichat N., Parschau M., Maciá B., Katsonis N., Harutyunyan S.R., Ernst K.-H. and Feringa B.L. (2011) *Electrically driven directional motion of a four-wheeled molecule on a metal surface*. Nature 479,

The Three Gaps Theory



Gebeshuber I.C., Gruber P. and Drack M. (2009) *A gaze into the crystal ball – Biomimetics in the year 2059.* 50th Anniversary Issue, Proc. IMechE Part C: J. Mech. Eng. Sci 223(C12), 2899-2918.

Governance and Risks

- Nanobioconvergence has implications on various areas – including health, environmental and social issues.
- Therefore, prospects, problems and potential risks are an important issue.
- Technological, environmental, societal, health, and safety issues must be addressed in research, societal studies, regulatory measures, and government policies.

Societal Implications

Societal implications of converging technologies should be judged using a balanced approach between the goals (leading to envisioned societal benefits) and unexpected consequences (which could be a combination of unexpected benefits and risks).

Gebeshuber I.C., Gruber P. and Drack M. (2010) *Nanobioconvergence*. In: Encyclopedia of Nanoscience and Society, Vol. 2, (Eds. Guston D. and Golson J.G.), 1st edition (July 14, 2010), Sage Publications, CA, USA, 454-456.

Conclusions and Outlook

- The fully exploit the potential of nanobioconvergence scientists and engineers will have to substantially change their methods and concepts of thinking, especially on the level of fundamental research.
- Interdisciplinary scientific principles and concepts that allow specialist scientists to understand complex phenomena need to be developed.
- The specialist results that currently appear in increasingly specialist journals need to be re-arranged and connected across fields.

Gebeshuber I.C., Macqueen M.O. and Majlis B.Y. (in press) *Nanobioconvergence. In: Nanotechnology in the edge of convergence*, Kulshreshtha A.P. (Ed.)


Terima kasih!