

## Where nanoscience and microbiology meet

*Nanoscience. Surely as one of the hottest areas in contemporary scientific research, there is an ever-increasing interest in this field. This FEMS Focus has taken the opportunity to explore the interface between nanoscience and microbiology. Tone Tönjum, Secretary General of FEMS, interviewed Ehud Gazit, a leading researcher and professor at the Department of Molecular Microbiology & Biotechnology, Tel-Aviv University, Israel. Read below about his views on the impact of nanoscience, the interface between nanoscience and microbiology, and potential use of nanoscience in microbiology.*

Nanoscience is concerned with the study of processes at the nano-scale by objects that are generally smaller than 100 nm. Much of the study of nanoscience relates to the phenomenon of self-assembly in which nano-scale building blocks self-associate to form complex structures.

Microbiology relates to nanoscience at a number of levels, Gazit says. Many bacterial entities are nano-machines in nature, including molecular motors like *flagella* and *pili*. Bacteria also form biofilms by the process of self-assembly (for example the formation of Curli-film by *E. coli*). The formation of aerial hyphae by bacteria and fungi is also directed by the controlled and ordered assembly of building blocks. Also, the formation of virus capsids is a classical process of molecular recognition and self-assembly at the nano-scale.

Another completely different aspect is the use of nano-ordered bacterial assemblies for nanotechnology. For example, in the pioneering work of Uwe Sleytr, bacterial S-layers are being used as masks for photo-lithography.

Nanoscience does have an impact on several areas of microbiology. It allows for the study and visualization at the molecular-assembly levels of a process. It facilitates identification of molecular recognition and self-assembly motifs as well as the assessment of these processes. These are relevant to many microbial processes as mentioned above.



*Ehud Gazit (with permission)*

***What is the potential use of nanoscience in microbiology and the impact on medical microbiology? What about the impact on the environment and environmental microbiology?***

Taking microbiology in general, nanoscience could be used both to understand as well as control processes at the molecular-assembly level. Just as bacteria were the first models to understand genetics and biochemistry that were later applied to eukaryotic systems, the same is true for the processes of function, recognition and assembly.

Turning to medical microbiology Ehud Gazit thinks of two immediate applica-

### *From the Editorial Team*

*Throughout time, microbiology has developed in many different directions such as microbial physiology, genetics, medical-, veterinary-, environmental-, evolutionary microbiology, aeromicrobiology, food microbiology and much more. To continue its developments, several areas in microbiology, and in particular medical microbiology, are now looking to new, emerging scientific fields, nanoscience among them. The nano-idea isn't as new as we may first think; it has been present – somewhat unnoticed or undefined – in our daily life, already in science fiction as a sort of technology that could allow characters to be or do almost anything and in the movies of the early sixties. Did you know that nanoscience has even been represented at a film festival? Recently, an award-winning, 30-minute film about nanoscience, 'When Things Get Small' was made. Co-supported by the National Science Foundation, this film was produced with the aim to make science entertaining. But watch out; there is a lot of hype surrounding nanotechnology. Reports with very little scientific basis can lead to misunderstanding and myths. The term "nano" is present in many fields – nano-biotechnology, nano-physics, nano-engineering, nano-chemistry, nano-medicine, etc... but you never hear about nano-microbiology. In this issue of FEMS Focus we try to bring together the facets where particularly the micro- and nano-worlds meet. Not an easy task, but an enticing one. We hope you will find this issue interesting.*

*Alenka Prinčič and Tone Tönjum, Editors*

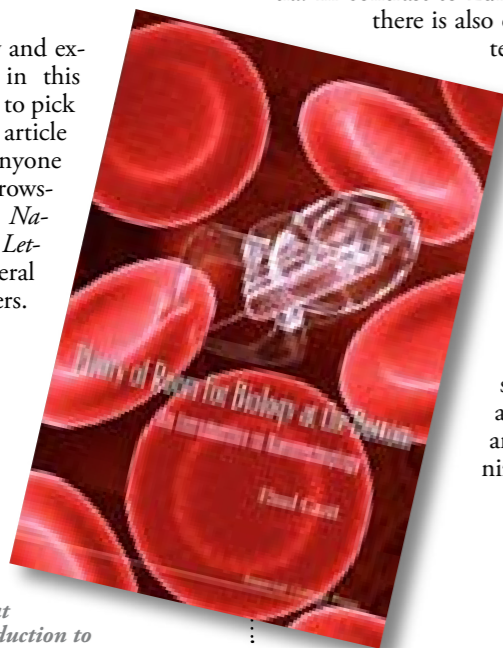
tions. The first one is the study of the process of biofilm formation, a key medical problem. The second one is the process of self-assembly of viral capsids. As we desperately need anti-viral drugs, this could be a very interesting target research field yet to be explored.

Nanoscience enhances the sensitivity of detection down to the single particle limit. This is critical for environmental monitoring as well as to homeland security - but this is yet another field of study.

*What is the newest cutting edge finding in this field? Can you highlight a recent "hot" article?*

There are many new and exciting publications in this field, so it is difficult to pick out an exceptional article without insulting anyone at the same time! Browsing through *Nature Nanotechnology* or *Nano Letters* alone brings several very interesting papers.

*What are the similarities and differences in the US and the EU nanoscience research?*



Gazit, E. Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology. Imperial College Press.

Ehud Gazit received his PhD (with distinction) in 1997 at Weizmann Institute of Science, Rehovot, Israel. He has visited several international institutes, such as Massachusetts Institute of Technology, and is currently conducting research and lecturing at the Tel-Aviv University as a Full Professor. He received several Awards and Prizes; The John F. Kennedy Award (highest award given by the Feinberg Graduate School) in 1997, Certificate of Excellence for Students in High Education Institutes, awarded by the Committee of Education of the Knesset (the Israeli parliament), 2006 Prize for excellence in research, The Research Council, Tel Aviv University, among others. He is a member of the managing board of the TAU Center for Nanoscience and Nanotechnology and one of the Strategic Research Program Leaders of the EC Nano2Life Network of Excellence. His research is directed towards the study of protein folding, misfolding and self-assembly. His work led to the identification of minimal recognition elements that facilitate the assembly of amyloid fibrils and novel ways to inhibit this process. His laboratory was the first to identify aromatic dipeptides that form nanotubes and nanospheres of unique mechanical and chemical properties. These nano-assemblies have been used for ultra-sensitive biosensor applications and the fabrication of metallic nanowires. He has more than 90 publications in leading journals including *Science*, *Nature Nanotechnology*, *Nano Letters* and *PNAS*, chapters in books, and more than ten pending patents currently at the National Phase in the US, Europe, Japan, India and Israel.

Dr. Ralph C. Merkle, Principal Fellow at the company Zyvex and winner of the 1998 Feynman Prize in Nanotechnology for Theoretical Work says that nanotechnology promises to let us inexpensively fabricate most products permitted by physical law, getting essentially every atom in the right place. An effective method of achieving low cost, Merkle continues, is to use self-replication. Nature shows that this is possible: wood is inexpensive despite the fact it is made of untold billions of complex molecular machines because a tree can make more trees. We could do likewise, making

molecular manufacturing systems able to make more molecular manufacturing systems - producing inexpensive products available to all. Merkle and colleagues will explore the fundamental principles underlying replicating manufacturing systems and examine the proposals that have been advanced so far, as well as the vast differences between proposed artificial systems and the remarkably adaptable and error-tolerant biological systems that have served as "proof of principal". In this context, microbes are interesting micro-manufacturers. ([www.merkle.com](http://www.merkle.com))

Nanoscience is much more mature in the United States than in Europe. Yet, nanoscience in Europe is certainly evolving in recent years. The European studies include a specific call for papers in the 6<sup>th</sup> and 7<sup>th</sup> framework programs as well as a network of excellence such as Nano2Life. American nanoscience research is done mostly in individual laboratories rather than in consortia. In contrast to European research area,

there is also quite some more interaction with industry.

Nanoscience is spreading to all fields of our life - academic, industry, business, government. Numerous institutions and organizations are focusing on nanoscience research and a multitude of events are currently organized on this topic.

# If it is *micro* it is almost *nano*

*Microbiology – the multidisciplinary science of microorganisms. With its roots in the 19<sup>th</sup> century, it matured into a scientific discipline concerned with the structure, function, and classification of these organisms and with ways of controlling and using their activities. It continued to evolve into the major subdivisions of microbiology, which include medical, industrial, agricultural, food, and dairy. Much is now known in the field of microbiology, and the advances are being made regularly. However, bearing in mind that we have studied only about 1% of all of the microbes in any given environment, microbiology can be considered in its infancy relative to some other biological disciplines despite the fact that over three hundred years have passed since the discovery of microbes.*

Nanoscience is primarily the extension of existing science disciplines into the realms of the extremely small and is, of course, much younger. It wasn't until the early 1980s, when a series of breakthroughs in instrumentation and in technology, such as the invention of new types of microscopy, made it possible to "see" or manipulate objects on the scale of a few nanometers. One definition of nanoscience is that it concerns itself with the study of objects which are anywhere from hundreds to tens of nanometers in size. Probably the best definition comes from the NanoSci-ERA©2006 ([www.nanoscience-europe.org](http://www.nanoscience-europe.org)): the term "Nanoscience" encompasses the common unifying concepts and physical laws that prevail in the nanoscale. Research in nanoscience is an interdisciplinary knowledge-generating activity that strives to understand these laws and how they govern the behavior of nano-scale objects of physical, chemical or biological interest.

**micro** – meaning (Greek) very small, usually smaller than 1 mm, denotes 10<sup>-6</sup> so a micrometer is one millionth of a meter.  
**nano** – Greek: dwarf - goes from small to tiny; the word "nano" means 10<sup>-9</sup> so a nanometer is one billionth of a meter.

If it is *micro* it is almost *nano*; however, going down from the micro- to the nano-scale is not a simple matter of size reduction. The transition between the "small" and the "tiny" involves a radical change in the scientific concepts applicable. The laws of physics that govern the macroscopic world of our everyday experience can be readily used to understand microscopic objects. However, they break down completely in the nano-world, because of the radically different length-scale hierarchies and the underlying quantum mechanical behavior of individual atoms, electrons, or photons.

That nanoscience is a new science discipline is evident from the large number of state-of-the-art books and research journals devoted to nano-research. Wiley-Blackwell, the publisher of the FEMS Journals, also publish

SMALL, a journal that received its first impact factor in 2006, the highest initial Impact Factor for a journal specializing in the field!

**Sources:**

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 McGraw-Hill Encyclopedia of Science and Technology, 5th edition, The McGraw-Hill Companies, Inc.  
 Britannica Concise Encyclopedia, published by Encyclopedia Britannica, Inc.  
[www.nanoscience-europe.org](http://www.nanoscience-europe.org) [www.nanoforum.org](http://www.nanoforum.org)

Popular journals in nanoscience & nanotechnology ISI category	Impact Factor
Nano Letters	9.960
SMALL	6.024
Lab-on-a-Chip	5.821
Biosensors and Bioelectronics	4.132
Nanotechnology	3.037
Microporous and Mesoporous Materials	2.796
Microfluid Nanofluid	2.615
Journal of Micromechanics and Microengineering	2.321
Journal of Nanoscience and Nanotechnology	2.194
Nano Today	-
Nanoscale and Microscale Thermophysical Engineering	-
Nature Nanotechnology	-

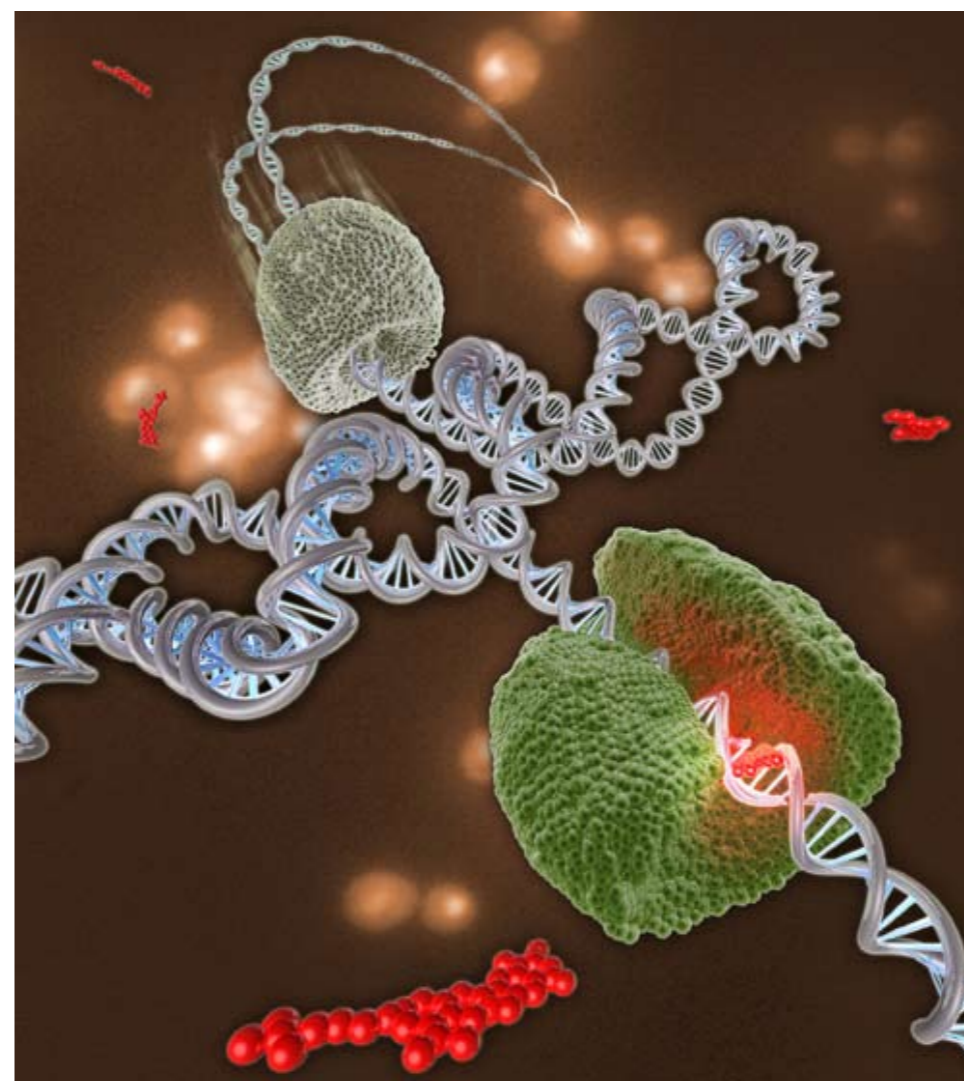
**Source:**

2006 Thomson Scientific (ISI) Journal Citation Reports® for the 'NANOSCIENCE & NANOTECHNOLOGY' category and Wiley-Blackwell

## ... nano @ FEMS

The Federation of European Microbiological Societies aims at promoting microbiology knowledge including its development in new directions. Nevertheless, nano@FEMS is still in its infancy as the FEMS journals do not specifically cover nanoscience among the scopes of the journals.

During the 2<sup>nd</sup> FEMS Congress in Madrid in July 2006, a workshop was devoted to the "nanotechnology in microbiology". The sessions were chaired by Uwe Sleytr from the University of Natural Resources and Applied Life Sciences at Vienna, Austria, Vitor Martins dos Santos from the German Research Centre for Biotechnology, Braunschweig, Germany and Ehud Gazit from Tel Aviv University, Israel. The keynote speakers presented up-to-date knowledge on quantification of vertical and horizontal gene flow across genomes and time, sequence-based prediction of the optimum growth temperature of uncultured bacteria, nanobiotechnology with S-layers, and on molecular self-assembly and fibril formation. FEMS will be looking forward to seeing such publications in our journals or to hearing new developments at the 3<sup>rd</sup> FEMS Congress in 2009.



Many biological processes happen on a nanoscale, and can be thus studied with biophysical techniques that can probe interactions on such a small scale (e.g. AFM, FRET, magnetic and optical tweezers). For example, topoisomerase release of DNA supercoils in the presence and absence of anticancer drug topotecan (the image) has been studied with magnetic tweezers in an unprecedented detail and was used to elucidate the topoisomerase mechanism as well as topotecan anticancer activity. Image by TU Delft & Tremani (with permission)



## Information and Funding opportunities...

Similar to microbiology, nanoscience and nanotechnology are now well established scientific disciplines, as is evident by the huge investment in nano-research facilities by research institutions and universities worldwide and by the growth of government funding programmes that specifically target nano-research.

Particularly interesting from America are the US National nanotechnology initiative ([www.nano.gov](http://www.nano.gov)) and the US NIH Nanomedicine road map (<http://nihroadmap.nih.gov/nanomedicine/>).

On the European front is the European Science Foundation nanotechnology programme (<http://cordis.europa.eu/nanotechnology/>). This web service provides an overview of nanotechnology related activities at the European Commission. The information provided on the portal complements similar information in other CORDIS or EUROPA websites; it highlights elements specifically relevant to nanotechnology in Europe such as the European strategy and the Action Plan, projects and funding opportunities in the Framework Programmes and related publications and events.

The Nano Science Europe, NanoSci-ERA ([www.nanoscience-europe.org](http://www.nanoscience-europe.org)), is a Consortium of 18 national research agencies from 12 countries in the European Research Area (ERA) whose objective is the coordination of the national policies in fundamental research at the nanometric scale. It was launched in March 2005, under the ERA-net scheme of the 6<sup>th</sup> EU Framework Programme for Research and Technological Development (FP6).

The European studies include a network Nano2Life ([www.nano2life.org](http://www.nano2life.org)). Founded in 2004, this is the first European Network of Excellence in nanobiotechnology.

The European Nanotechnology Gateway, NanoForum ([www.nanoforum.org](http://www.nanoforum.org)) was originally funded by the European Commission through FP5. Since July 2007 it has been operating as a European Economic Interest Grouping (EEIG). It continues to provide news items from across the EU including information from projects and organizations, and offers customers a powerful advertising and dissemination service through its network.

## Register as an Affiliate!

FEMS invites you to register as a FEMS Affiliate through the website. This registration is not related to the member societies, you just need to be interested in microbiology and in FEMS. As a FEMS affiliate you get access to several new initiatives and interesting microbiology-related information such as events, job vacancies and links. You will be kept up-to-date about relevant grants deadlines, about the suite of five FEMS journals and you can participate in an electronic forum called E-debate, based on controversial topics published in our journals.

FEMS has just launched a new web page *Pioneers in Microbiology*. Check it out on [www.fems-microbiology.org](http://www.fems-microbiology.org) and find articles on important historical scientists from your country that have shaped the course of microbiology in Europe such as Marko Anton Plenčič, Robert Koch, Anna Kocková-Kratochvilová, Hans Laurits Jensen, Gerhard H A Hansen, and many more. Do not hesitate to contact the Editorial team if you would like to contribute to this overview on the web.

### FEMS Meeting Attendance Grants

**DO NOT MISS IT!**

The closing dates for receipt of applications are April 1 and September 1, 2008.

Full details of conditions and application procedure are given online at [www.fems-microbiology.org](http://www.fems-microbiology.org) or can be obtained from [grants@fems-microbiology.org](mailto:grants@fems-microbiology.org).

### FEMS/ESCMID Fellowship

The recipient of this Research Fellowship in 2007 is Isaac Corbacho.

## ...from the European Commission in Brussels

### Workshop

An EC-US Workshop on nanobiotechnology will be held June 3-4, 2008 at the European Commission's Joint Research Centre located in Ispra, Italy. The meeting, organized by the "European Commission - United States" Task Force on Biotechnology Research, will focus on current status and potential developments of nanobiotechnology research. Particularly, the EC-US Task Force has been working on this topic since 1997, from then on this new frontier of biotechnology has grown rapidly developing innovative concepts and bringing to the market high added-value products. More information on the EC-US Workshop on Nanobiotechnology is available at: [http://ec.europa.eu/research/biotechnology/ec-us/index\\_en.html](http://ec.europa.eu/research/biotechnology/ec-us/index_en.html)

[www.fems-microbiology.org](http://www.fems-microbiology.org)

### What's next

The new FP7 thematic area of Nanosciences, nanotechnologies, materials & new production technologies is expected to be published next on [http://cordis.europa.eu/fp7/cooperation/nanotechnology\\_en.html](http://cordis.europa.eu/fp7/cooperation/nanotechnology_en.html). The core objective of this theme is to improve the competitiveness of European industry and generate the knowledge needed to transform it from a resource-intensive to a knowledge-intensive industry.

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