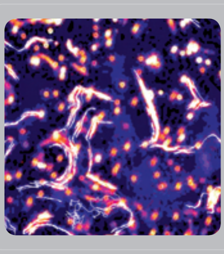
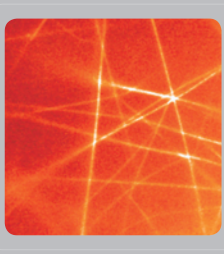
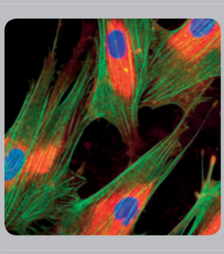
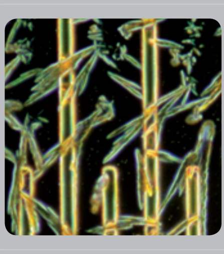
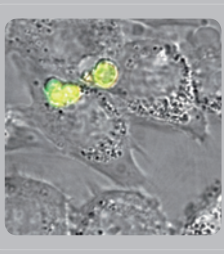
Global Challenges

How Can Nanotechnology Help?



CeNS
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SNI
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1 FOREWORD

As a key technology of this century, nanotechnology is expected to play a leading role in the development of solutions for our global challenges. Raising the awareness for these emerging challenges, particularly amongst the future generation of scientists, seems essential for the development of successful solution strategies.

Since these global challenges will require internationally consorted efforts, a group of 40 PhD students and postdocs from all over the world, working in different fields of nano-science gathered at the Venice International University on San Servolo for a concise and focused workshop to discuss these challenges as research opportunities, and to initiate a network amongst those scientists which will sculpture our scientific and technological future.

A CHALLENGE FOR THE FUTURE GENERATION OF SCIENTISTS

Between April 20th and 24th, 2008, the Center for NanoScience Munich and the Swiss Nanoscience Institute Basel organized and financed a workshop with the goal to raise the awareness of the next generation of nano-scientists to the global challenges looming on the horizon. Since these global challenges will require internationally consorted efforts the creation of a network of those scientists which will sculpt our scientific and technological future seems essential. Postdocs and senior PhD students from a broad range of countries from all continents were invited with the goal to initiate a global network amongst them. Particular emphasis was given to the participation of students from developing and threshold countries, as well as on ethnic and gender balance. As co-organizers the Abdus Salam Institute for Theoretical Physics, the Chinese Academy of Sciences and the Indian Institute of Technology in Madras were integrated. The participants were delegated by their respective mother institutions.

Three major goals motivated the workshop

- ☐ Identification of global challenges viewed from the student's perspective: From gofer's perspective of the lab to eagle's view of the world!
- ☐ Focusing on those topics where nano-science may contribute to solutions: Convergence with other technologies with the goal to develop high tech solutions as well as sustainable low-key technologies.
- ☐ Initiation of a global junior nano-scientist network: Direct personal contacts make joint projects possible which otherwise might be stuck in the mud-holes of bureaucracy.

HOW TO ADRESS THESE CHALLENGES? FORMAT OF THE WORKSHOP

Suitable formats for the different parts of the workshop were chosen to account for the diversity of both the research topics as well as the participants' cultural backgrounds. The majority of the participants had training in Physics with scattered Chemistry, Biology and Engineering experiences.
The workshop was structured in the following working blocks:

What can I contribute?

In the first block of the meeting each participant introduced him/herself in a 5 minute talk followed by a poster presentation in the afternoon session. The topics ranged from atom manipulation to artificial photosynthesis and covered systems as simple as single spins and as complex as protein networks in cancer.

Emerging global challenges

For the second block an experimental format was chosen. In roundtable discussions in six groups the topic "Identify global challenges" was first expanded in two rounds. A chair kept the "wisdom of the table" and passed it from round to round while the discussants redistributed between the tables such that ethnic and gender entropy was maximized. After the second expansion the tables first agreed on criteria and then narrowed down a concise list of global challenges.

Within the broad range of challenges the group decided to focus the discussions on those problems where their expertise allowed a meaningful judgment and where nanotechnology promises to become instrumental, well knowing that their selection covers only a minor part.

Here nano can help!

In the third block potential contributions from nanoscience to solutions of global challenges were elucidated. For this task the format of focused discussion groups was chosen. The discussants now arranged themselves into six groups each concerned with one of the identified topics. Due to the uneven distribution

amongst the different disciplines (Physics dominated) certain topics like energy attracted more participants for the discussions than topics like food.

The outcome is summarized in Table 1.

Let's team up globally

The fourth and last block was deliberately left unstructured. Since the participants had, in the first block, gotten a glimpse of the expertise of the other participants and had, in the following blocks, experienced their scientific options in greater detail this last block now allowed them to exchange concrete research ideas with their peers and to team up for cooperation projects. Typically two or three partners joined together and came up with brief concepts highlighting the basics of their idea which they presented to the group.

2 CHALLENGES ARE OPPORTUNITIES! ANALYSIS & SUGGESTIONS

In the first round of the discussions in small groups a broad list of topics was identified where nano-sciences are expected to be able to contribute to the solutions. However, the ranking of these topics proved to be very difficult.

2.1 CRITERIA FOR GLOBAL CHALLENGES

For the assessment of the discussed challenges, several criteria were proposed and rated for their relevance. In a next step, the identified challenges were analyzed by the most relevant criteria in order to establish a ranking of the previously identified global problems.
One of the prevailing criteria was found to be the global impact of the respective challenge on humankind. The question of whether a large part of the world's population - independent on their economic and demographic condition - is affected dominated the evaluation of a specific problem. Evidently, the urgency to find solutions played a major role in the rating of existing global challenges. However, the time scale for eliminating a problem and the rate of change related to it were identified as minor issues compared to the urgent need for finding promising opportunities. In addition, while the sustainability of a solution is considered an important criterion, the potential of loss associated with the problematic topic was regarded as less crucial. Other significant considerations are the ethical-social implications related to possible solutions taking into account the need for public acceptance of a new technique in order to successfully introduce it. Furthermore, the costs associated with the development of solutions were considered a major criterion, in contrast to the economic profit related to the possible new product or technique. On the other hand, while the feasibility of a possible problem-solving option in general is evidently of utmost importance, the potential for finding a solution based on nanotechnology is an even sharper criterion used in this workshop owing to the scientific background of the participants. This restriction directly implies that only problems that can be addressed with the help of nanotechnology are included in our list of global challenges. For that reason, issues like the growth of the world population as well as political and religious conflicts are not discussed.

In summary, five major criteria for the evaluation of global challenges were proposed:

- Global impact
- Urgency
- Potential for nanotechnological solutions
- Sustainability
- Costs

These criteria were used to identify six global problems, which were found to be of highest importance in this nanotechnology-related context:

- Education
- Energy
- Environment
- Food
- Health
- Water

The list is in alphabetic order since the discussants could not agree on a strict ranking based on relevance. Table 1 provides a summary.

2.2 EMERGING GLOBAL CHALLENGES AND HOW NANO COULD HELP

Having the global challenges defined according to the determined criteria, solutions for the specific problems where discussed and checked for the potential for nanotechnological contributions. Owing to the interconnectivity of the topic of energy with the environmental issue, these two challenges were merged together for the discussions. The complexity of the energy problem led to the division into two subtopics: production/transformation and storage & consumption of energy.

Global Challenge	Urgency	Global Impact	Sustainability	Ethical - Social Implications	Nanoscience potential	Costs
Education ☐ Access to education ☐ Knowledge transfer ☐ Network / Collaboration	+	Primary in developing countries	Yes	Very important	Cheaper electronics, OLPC	Cheap
Energy ☐ Production ☐ Consumption ☐ Storage ☐ Distribution	++	Global importance	Depends on the source of energy	Important for life style, culture, industry	3rd generation solar cells, hydrogen storage, LED, ...	Depends on source / price
Environment ☐ Pollution ☐ Biodiversity ☐ Climate Change ☐ Recycling	++	Global importance	Yes	May have short term disadvantages for some people	sensors Nanoparticles/ polymers fighting catastrophes, catalytic CO_2 reduction, ...	Costs out weighted by costreduction due to reduction of pollution
Food ☐ Increase Productivity ☐ Quality ☐ Distribution	++ (developing countries)	Only for developing countries	Possible	Genetically modified food not generally accepted	Genetically modified food	Depends
Health ☐ Diagnosis ☐ Prevention ☐ Therapy	++	depending on disease and country	Depends on the kind of disease	Accessibility, IP sharing, Animal testing	drug delivery Diagnostics, specific targeting, ...	Potentially dangerous (direct exposure to human body) + Potentially cheaper
Water ☐ Purification / Desalination ☐ Distribution	++ (developing countries)	Only for developing countries	Depends on method	Free access to water important	purification, desalination, ...	Depends on technique

Table 1: Global challenges and criteria for their evaluation.

Education

In this area, concerns about education and knowledge in general are considered. The issues discussed can be roughly divided into three topics:

- Access to education
- Knowledge transfer
- Networks & collaboration

Education is considered to be a very important tool to achieve development and help fight poverty. Enabling access to education would be an asset.
Knowledge transfer has different aspects. On the one hand it is very important to improve the networking and exchange between scientists around the world and foster international and intercontinental collaborations to achieve a more equitable distribution of technology and its benefits. On the other hand, the communication of scientific knowledge to different sectors of society outside the scientific community is also considered to be of high relevance. This includes a certain control on the responsible use of scientific results, as well as an open dialogue with the public. The former refers for instance to intellectual property rights (like, for instance, monopoly by a company on a medicine) and military oriented research applications. A further point related to the communication of science is the prevention of misconceptions related to emerging technologies, which lead to reticence and sometimes moratoria of research (e.g. stem cells research).

Potential help of nanotechnology for education:

In the discussion on how nanotechnology may be instrumental, the topic was divided into three parts:

- Basic education (school)
- Higher qualification (employees)
- Knowledge distribution

As an option for the improvement of education in the developing countries, simple and for everybody accessible solutions are of utmost importance. In this context, the development and distribution of a cheap computer like the intended 100$ laptop seems promising (project "one laptop per child (OLPC)" http://laptop.org/). Here, cost-reducing effects based on new nanotechnological methods for the production of computers could contribute. In a next step, a network of these laptops could be established in order to connect the users and promote the exchange of knowledge.
In the view of providing higher, secondary education for employees, new high-school programs and the establishment of closer cooperation between different companies and various countries were proposed. The implementation of high-tech industries in the developing countries would create qualified jobs enhancing the autonomy of these countries. Here, nanotechnology could have an impact by providing the knowledge for cutting-edge techniques in the high-tech sector.
An important topic for the improvement of education in developing countries is the worldwide sharing of knowledge. This goal can be fostered by offering open-source software and free access to information in journals and other data-bases. Exchange of ideas by enhancing mobility between the developing and industrial countries (into both directions) would make a large contribution to the efficient transfer of knowledge. An additional important point is the involvement of researchers in government bodies by providing consultancy to the decision-makers with respect to important issues like safety and environment.
With these approaches, an interconnectivity between education and (nano-)science will be established which stimulates and promotes both matters.

Energy

This topic attracted most of the discussants, which might be influenced by the fact that the majority of the participants were trained in physics. The issue of energy was divided into four main aspects:

- Production / Transformation
- Consumption
- Storage
- Distribution

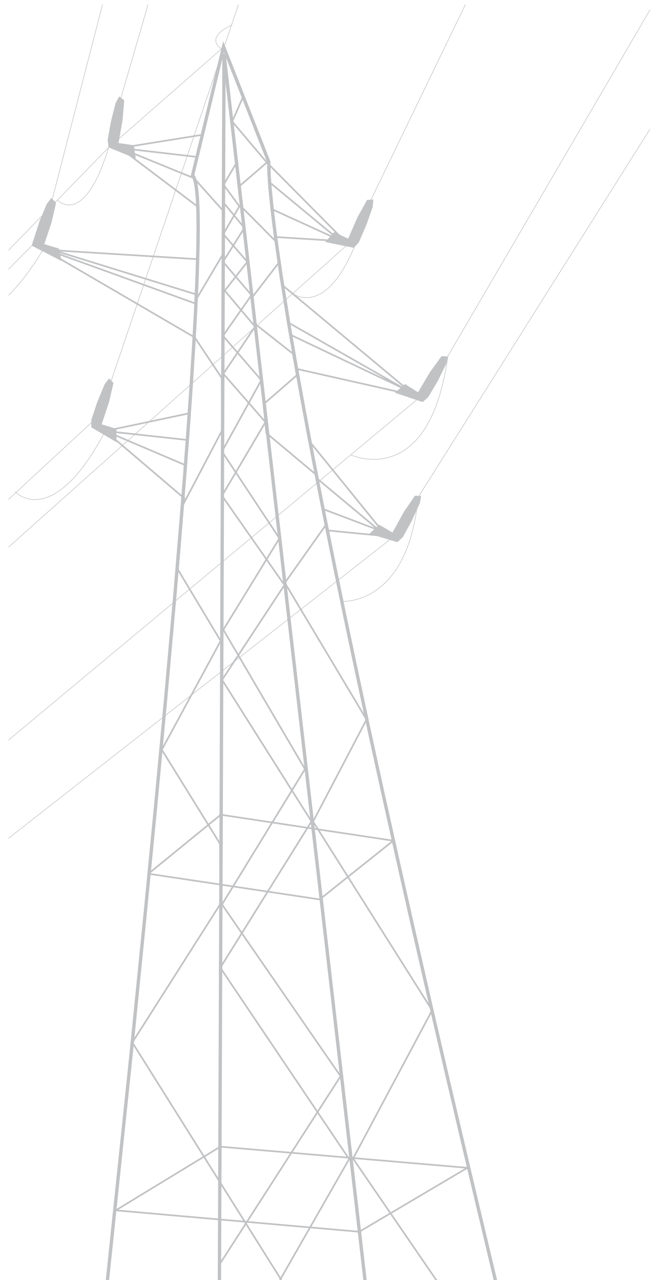
On the one hand, new sources of renewable energy are needed which can cope with the current and foreseeable consumption of energy. On the other hand, the standard of living should not suffer from the eventual shortage of energy. Therefore, reducing the consumption of energy by means of more efficient devices and processes is also an important aspect to take into account.

Storage and distribution of energy play also a very important role; if most of the energy produced is lost in the distribution line or cannot be properly stored for long times, the production level needs to increase drastically. The energy distribution was also pointed out as an important issue in view of the equal access to this resource, independently of the regions where it can be produced best.

A further point assessed was the recycling or appropriate disposal of the new devices to be developed.

Potential help of nanotechnology for storage and consumption of energy:

The question of storage and consumption of energy can be widely addressed by nanotechnology. For a realistic use of hydrogen cars driven by fuel cells, the problem of the efficient H_2 storage has to be solved. Basic research suggests that carbon nanotubes, fullerenes and zeolites could offer feasible options. For the storage of electrical energy, nanotechnological improvements of Li-ion batteries, novel nanocapacitors and organic batteries engineered by three-dimensional molecular self-assembly are promising opportunities. With respect to energy consumption, the way to go is to make the existing technology more efficient and reduce losses. In the field of electronics, energy-saving lighting (LED) and the reduction of power loss and joule heating are important points to consider. Possible nanotechnological solutions could be provided by exploiting molecular electronics, superconducting wires or nanocrystalline diamond. Reduction of the energy consumption in daily life requires the global implementation of efficient lighting, better isolation of buildings and use of equipment with self-cleaning surfaces. On a larger scale, reducing the reaction temperatures in industrial applications and the use of light



materials (e.g. composites of carbon nanotubes) in the automotive sector would make a major contribution to lowering the consumption of energy and fuel.

Potential help of nanotechnology for energy transformation (production):

Based on the technical expertise of the participants, the following sources of energy were selected for discussion:

- Photovoltaics
- Fuel cells
- Fossil (coal, oil, gas)
- Heat recycling
- Photothermics
- Bio / Chemical Energy

The criteria to take into account for the proposed ideas are

- Scalability (the ability to cope with the rapidly increasing consumption of energy)
- Sustainability (environmental impact)
- Power density
- Costs
- Distribution (centralized production vs. decentralized)
- Continuity of the production

In the field of photovoltaics, the systems currently in use are contributing only slightly to the generation of renewable energy. The main reason is the unfavorable power payback time (i.e. the ratio between the energy consumed by the device and the electrical energy produced by the cell). Further limitations are the location dependent power density, the necessary storage systems and the fact that sustainability is not assured and depends on the material (CdTe, In, Ga, high quality silicon). Nanotechnology could help the further development of photovoltaics by providing new materials, basic physical knowledge, increasing efficiency and cost reduction. Fuel cells are very promising candidates for future energy transformation (highly mobile, scalable). However, the limitations at the moment are manifold, namely, the lack of suitable materials (i.e. catalysts) and fuel sources, as well as the need for the development of complex infrastructures. Again, nanotechnology could provide new materials (i.e. catalysts), basic physical know-how, increasing efficiency and cost reduction.
The most prominent resources for energy transformation are the fossil fuels (~85 % of the world's energy use). The combustion of coal, oil and natural gases is however not an option in the long term, but is the most commonly used and well known technique at the moment. The positive side of using fossil fuels is that in the short term a high efficiency can be reached (up to 90 %). The drawbacks are the emission of CO_2 and the fact that these resources are finite. The contribution of nanotechnology could be to provide new materials for CO_2 filters and to develop more efficient fuels (i.e. nano powders).
Heat recycling aims to use the heat produced by running machines, e.g. industry and households, to generate electrical energy. The usage of this energy is often a relatively easy engineering task and is in principle applicable everywhere. The problem with this technique is that heat transformers are missing appropriate materials and have a low efficiency. Here, nanotechnology could provide new materials (thermoelectric), basic physical knowledge, increasing efficiency and cost reduction.
Bio-inspired/chemical energy is very actively researched and could become a very important source of energy in the future. One example in this field is the omnipresent process of photosynthesis. The harvesting of solar energy and its subsequent conversion into stable products depends on an interconnected macromolecular network of membrane associated chlorophyll-protein complexes. These efficient and robust molecular aggregates of different light harvesting systems in nature inspire us to use purified components as molecular photonic structures in nanotechnology. For example, in natural photosynthetic systems, a vast number of chlorophylls are necessary per light converting unit. Without antennas the whole surface would need to be covered by converting units not operating at maximum efficiency. Candidates for the implementation of such antennas could be natural antennas isolated from purple bacteria, self-assembled chromophore nanostructures or covalent multichromophoric systems (large dendrimer molecules with well-defined structures). Nanotechnology could provide cost effective antennas with high absorption cross sections in a broad wavelength region, new organic materials (bacteria), basic physical knowledge and risk assessment.
The production of clean fuels can also be envisioned by means of water splitting microorganism and anaerobic bacteria, for example by developing strategies to catalyze the enzyme that produces H_2 , in order to increase the efficiency of the process.

Environment

Environmental problems were to a large extent considered under other categories like water and energy. Some of the more specific problems not included in the former categories are

- Climate change
- Recycling of materials
- Biodiversity
- CO_2 concentration
- Oil cleaning
- Other forms of pollution not considered before in connection to water

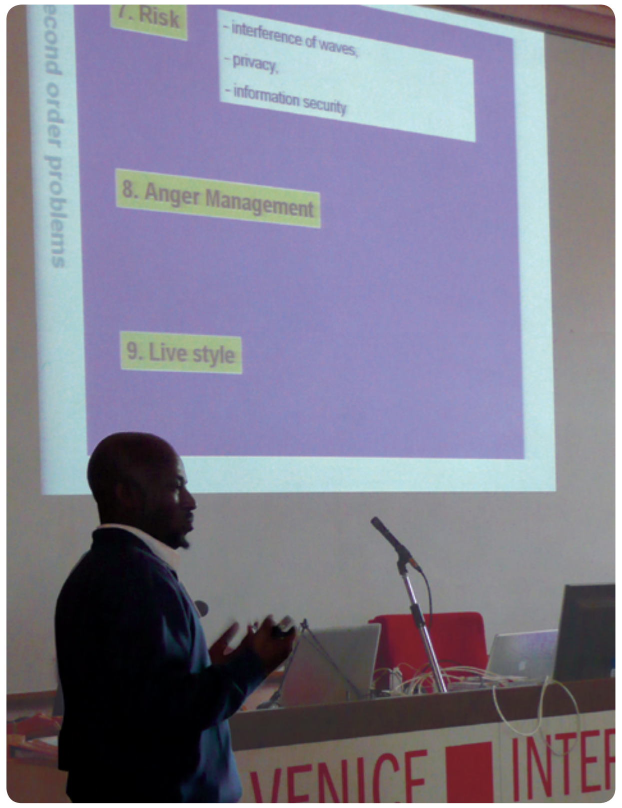
Another point addressed was the need for a risk assessment on nanotechnologies, as a mean to prevent possible negative impacts of new developments on the environment.

Health

Improving health may and should be approached from three different directions:

- Diagnosis
- Prevention
- Therapy

The negative impact of many diseases relies on the fact that they cannot be unequivocally diagnosed or a diagnosis can be first done at a very late stage of the evolution of the disease. A trustworthy early diagnosis could save many lives.
Prevention is of course highly desirable, in any possible case. Especially important is prevention in the case of epidemics and contagious diseases, for which a cure has been very challenging until now.
Considering therapy, it was stressed that treatment must focus on the cause of a disease and not on the symptoms.
In general, viruses (e.g. HIV) and cancer were pointed out as the most relevant diseases to concentrate on.



Potential help of nanotechnology for health:

A summary of the potentials of nanotechnology for medical applications is illustrated in Table 2. The most relevant problems related to health were identified and a set of specific criteria relevant to these problems was used to evaluate the possibilities of nano sciences to improve the current situation. In a second step some concrete examples of nanotechnological developments in the field of medicine and biology were discussed. Tissue engineering, for instance, can help improving the acceptance of implants by the body by covering the implant with specially designed tissues. Some researchers go a step further and envision even the growth of artificial organ tissues leading to a donor-free "transplantation".
For the diagnosis and treatment of diseases, in particular of cancer, functionalized nanostructures were considered. These structures, generally made out of liposome or polymers, are built as containers and functionalized on their surfaces, depending on the application they will be used for. Through functionalization, selected areas of the body can be targeted. The containers can be filled with fluorescent substances for diagnosis or different pharmaceutical substances for treatment. Furthermore, structures like nanotubes or quantum dots can be built in and activated once in the target by heat or magnetic fields. Tests in this field are carried out for realizations of these structures. On a more speculative level nano-structures were conceived with the ambition of having a multifunctional device which could diagnose, or locally apply treatments.
Sequencing of DNA could become very fast with the help of nanopores. These very small pores in electrically insulating membranes help speeding up DNA sequencing, distinguishing between single and double stranded DNA, and determining the length of polymers.

Disease	Urgency	Long / Short Term Feasibility	Diagnostics Is it possible?	Treatment Is it possible?	Nano-based Techniques	Drug Screening
Blood Disorders	+	+	Yes	Yes	Gene Delivery	Already in practice
Cancer	+	+	Already available – but can improve early diagnosis / sensitivity	Yes (for most not all!)	☐ Biomechanics ☐ Nanoparticle / CNT based detection / treatment for imaging, drug release and tumor elimination	Yes
HIV	+	+/ -	Available already – but need early diagnosis / sensitivity	Symptomatic treatment	Protein / DNA Arrays	After mechanisms are better understood
Implants	+	+	N/A	☐ Removal of side effects ☐ Tissue Reconstruction via functionalized inorganic scaffolding ☐ Electrical Implants	☐ Stem cell therapy ☐ Tissue engineering ☐ AFM for differentiation/ commitment ☐ Gene delivery to suppress immune reaction	Targeted delivery
Malaria	+	+	Available already – can possibly improve with nano	Yes	☐ Biomechanics ☐ Microfluidics	Yes
Neuro-degenerative Disorders	+	+/ -	Possible but very challenging as mechanisms / markers are unknown	To a limited degree	☐ Biomechanics? ☐ XRF (initial research in progress for Alzheimer`s Disease)	Possibly

Table 2: Potential of nanotechnological approaches for medicine.

Food

How to increase the productivity of food is as important as challenging. The use of fertilizers and pesticides generates pollution and reproducible genetically modified aliments (in opposition to non-seed species) could affect biodiversity. How to overcome these drawbacks is key to avoid increasing food productivity in detriment to other problems considered in the previous categories.
A supporting measure to relax the demands on the food productivity is the control of the properties of food. The goal here would be to achieve a certain quality of the produced food to meet the standards of conventional food with a significantly smaller amount of it.
As for other resources already mentioned, the equitable distribution of food is of most relevance to solve nutrition problems at a global level. As the current discussion in the context with bio-fuel reveals, this problem has to be seen in the context of energy production and water.

Potential help of nanotechnology for food problems:

The task of providing enough food for the world's population is undeniably an urgent global challenge affecting severely the developing countries. While the availability of water is evidently a basic requirement for agriculture, some of the causes for the lack of food in some parts of the world are related to the low efficiency of the food production with respect to the use of land and water. Moreover, the increasing consumption of meat, which has much lower conversion efficiency than corn and rice, worsens the problem. Nanotechnology can probably help developing possible solutions by increasing the efficiency and resistance of plants by genetic modifications which bring along several risks and political restrictions. The improvement of soil by the development of multiwalled nanofertilizers exhibiting long-lasting effects was another discussed option. More futuristic propositions consisted in the accumulation of water from air by nano-porous sponges, the design of substitutional

food (e.g. synthetic meat) and the use of postharvest stems and sea organisms (sea plants, planktons) for human consumption. Another possible solution which is already planned in Japan and China is implementation of vertical farming. This new technique consists of a fully automated closed system, where farming is performed directly within urban skyscrapers, making it possible to fully optimize and control efficiency-enhancing parameters.

Water

Water is one of the fundamental resources for life by itself, having also a big impact on health and food production. Three main aspects were identified:

- Purification
- Distribution
- Testing

The purification of water is not only relevant fo human consumption, but also for an equilibrated environment in general. Water can easily transport and diffuse diseases and toxic substances, but the irrigation of plantations and fishing depend on clean waters. Purification of water is not only limited to cleaning polluted water but it also includes the treatment of waste water and desalination. Given that most of the earth is covered with salted water, desalination is a suitable way of gaining access to this valuable resource.
Distribution of clean water is a key point to be addressed. This resource should be distributed with equity. In addition to the obvious benefits of it, this could even prevent wars in certain regions of the world. In order to prevent diseases and develop purification methods, an efficient and reliable technique for water testing is indispensable.

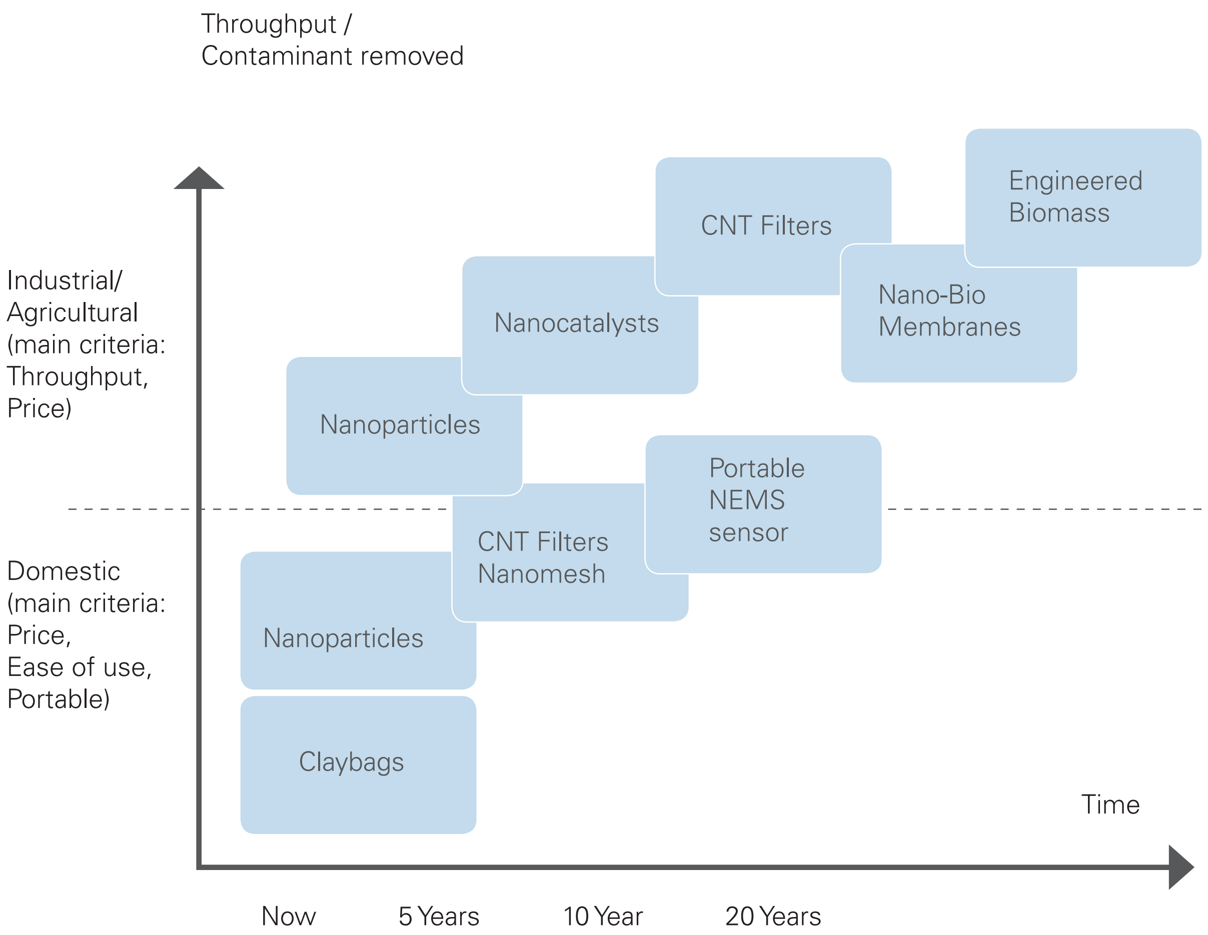
Potential help of nanotechnology for water problems:

Many nanotechnology products for the treatment of water are already in the development stage. Examples of these developments are

- Nanocatalysts and Nanoparticles for bacteria and pesticide removal
- Nanomesh in water sticks (being tested in proto types)
- Carbon Nanotubes membranes (for all contaminants, desalination; expected to be ready for a wide use in ~ 5-10 years)

However, further developments and contributions can be achieved using nanotechnology. An example proposed was the use of polymer membranes for desalination. Currently, the major desalination technologies in use are based on membrane separation via reverse osmosis. This process consumes energy mostly by raising the pressure of the water to be filtered. Since the pressure has to be set every time a container is refilled with water, the consumption is high due to the frequent repetition. Polymer membranes with inserted aquaporins would be a very good alternative. These proteins are very selective and efficient water filters. They naturally appear in many organisms and are responsible for the regulation of volume and internal osmotic pressure of cells, the re-absorption of water from the primary urine and water absorption in the root of plants, to mention some examples. This

protein has a narrow channel which only allows water molecules to pass but no bigger molecules and no ions. The permeability of water is quite large, so it is a very efficient and effective way of filtering water. Another idea proposed for the detection of contamination in water is a cantilever sensor array. The cantilevers used for scanning probe microscopy are very sensitive to small changes in their bending due to mass deposited on them. By adequately functionalizing these cantilevers with receptors for the substance to be detected, the deposition of such substances can be detected with a very high sensitivity. This device could drastically speed up tests and have a huge increase in sensitivity compared with current methods.
It was mentioned that further directions to explore for improvements are waste treatment in water and transport of clean water. The former has to be of low cost, since it is related to industries, which have huge volumes of waste to be treated. Often microorganisms are used for this purpose and nanotechnology could contribute by genetically modifying these organisms in order to increase their effectiveness. In the case of water transport, new materials could be key. Desirable would be materials for the transport which are chemically inert and multifunctional; for example materials which transport and at the same time purify the water.
A summary of the techniques considered with respect to their use and the time scale in which they are expected to be ready for their application is given in the scheme below.



3 A Global Junior Scientist Network Evolves

In a last block participants started to capitalize on the existing expertise of the group and to put forward new ideas in an interactive fashion that eventually should lead to an international network. Valuable possible projects in the different identified areas have been established. However due to their preliminary state and reasons like IP only a very limited selection will be incorporated in this report and also here the description of the projects must stay at the surface.

Science of interaction

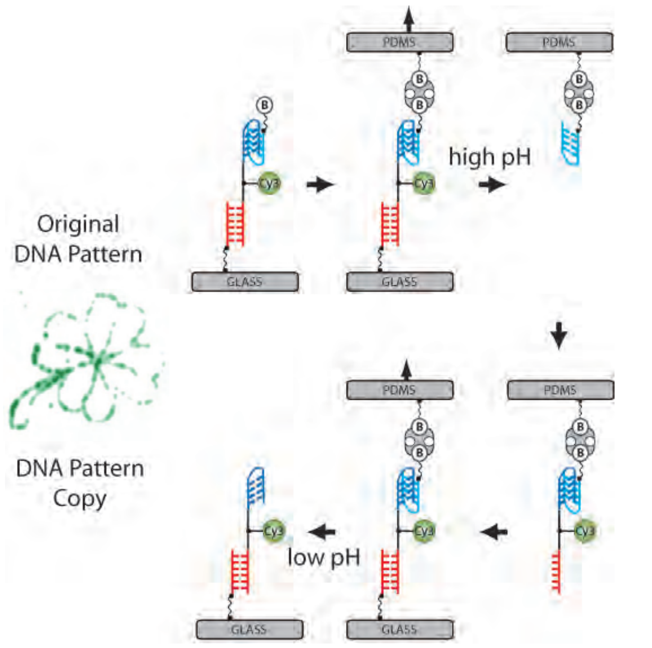
In a very general contribution the nature of the network to be formed was discussed. A transition from "unidirectional information technology" towards a "science of interaction" with horizontal communication pattern was demanded. Instead of the traditional posting of information, questions that are asked should characterize this unidirectional communication network, which hopefully find answers amongst the peers. A cooperation with the NSF Initiative Science of Interaction -"enabler and catalyst of 21'st century science" was suggested.

Novel DNA-chips for inexpensive testing

A Pakistani-Iranian-German cooperation spontaneously evolved out of the discussions in the "Health" group. A novel DNA chip format was proposed where the chips are first programmed by single molecule "cut & paste" technology and then copied and multiplied by stamping techniques. Potential applications are seen in inexpensive multi component testing for diseases but also for environmental hazards.

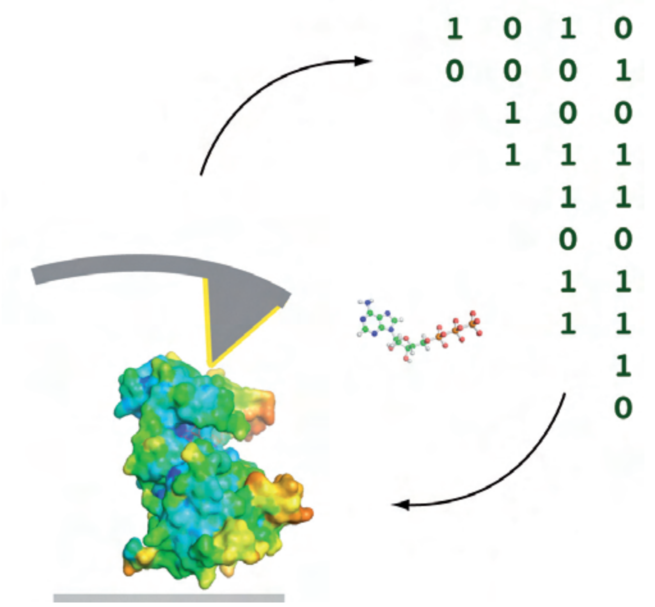
Differential force assays for multi component screening

An alternative technique with a complementary goal was suggested by a Chinese-German group. They want to employ differential force assay techniques for testing with the chips produced in the project above and alternatively also exploit the pH dependence of i-motif structures for the printing of nanoscale patterns of binding sites.



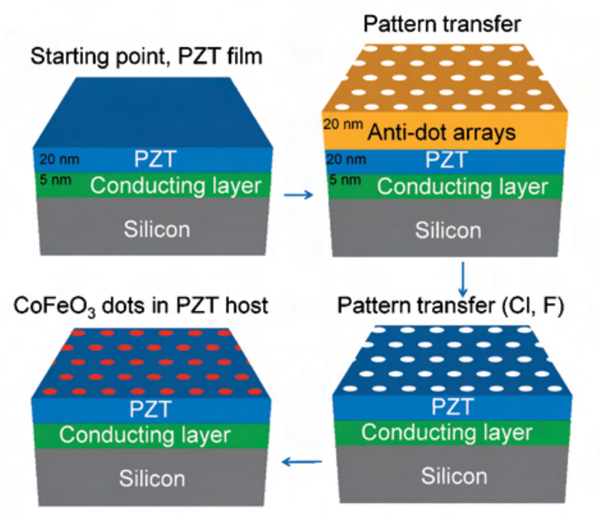
Novel drug design strategies for developing countries

A cooperation project between Chinese and German participants suggests combining Molecular Dynamics simulations with high throughput single molecule force spectroscopy for drug design and screening. With partially coarse-grained algorithms they plan to first model the receptor binding pocket for drugs and then to validate the predictions for the affinity by AFM based techniques in an iterative manner. A particularly important potential is seen in the development of such drugs which are urgently needed in the developing countries but for which the established companies see no market opportunities.



Lighter and sturdier materials

An inter-Chinese cooperation sprung up with the goal to develop novel materials with improved properties for reduced energy consumption. Synthetic silk fibers are in the focus of this project. Design rules from natural silk fibers and from synthetic Nylon fibers will be combined and the resulting properties will be both simulated by suitable modeling techniques and investigated experimentally.

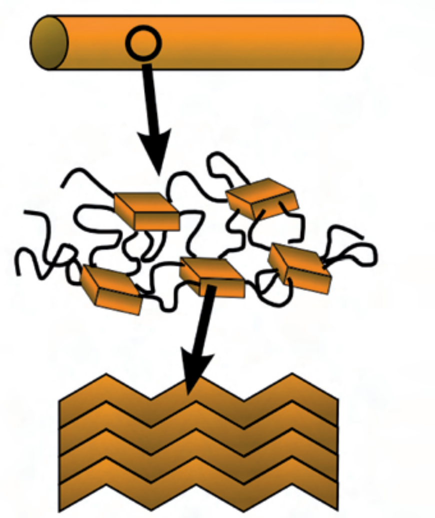


Novel nano-particles

A second inter-Chinese cooperation focuses on the creation of novel nano particles e.g. for drug delivery based on viruses. Control on the self assembly process of the virus capsid shall be gained by protein engineering assisted by Molecular Dynamics simulations. Specific docking sites shall be designed based on results obtained in the cooperation described earlier. Potential applications are seen in novel formulations of pharmaceuticals particularly designed for the cure of the diseases listed above.

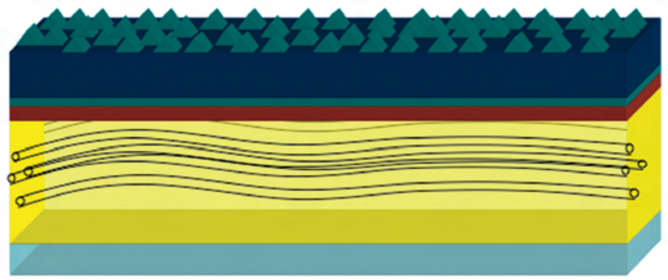
Novel nano-patterning techniques for memory devices / voltage generators

A group with members from Ireland, Cameroon, Germany and India plans to combine novel nano-patterning techniques for the creation of a new type of memory devices and voltage generators.



Energy saving multifunctional coatings

A very appealing proposal for a low cost multifunctional coating for buildings evolved from the discussions in the energy group and was proposed by an Austrian-German Group. This novel coating concept combines several environmentally beneficial functionalities in a hybrid-multilayer system. Research in the contributing groups should help to determine the length scale for the nanostructures on the surface for an optimum of self-cleaning effect and light absorption.



4

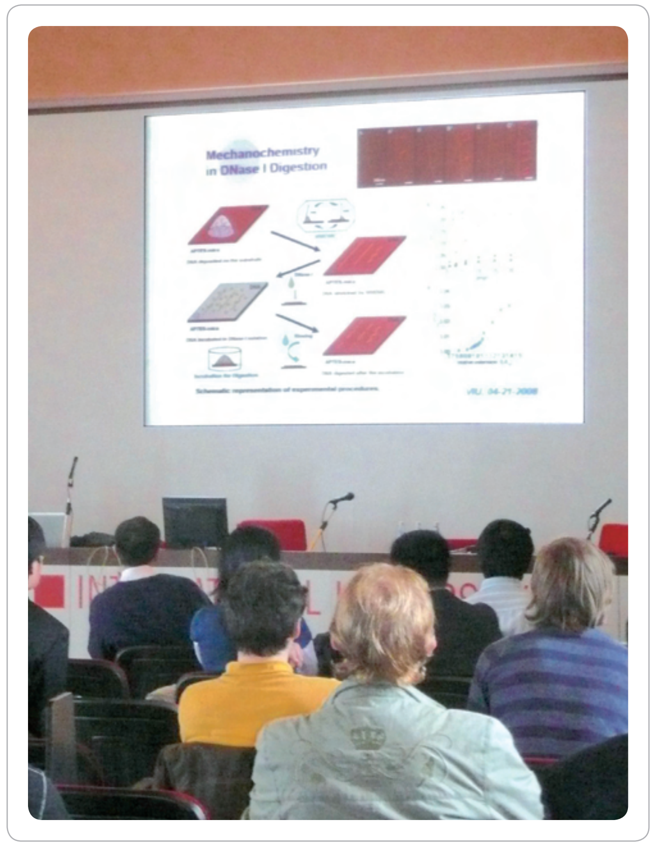
Conclusions

Feedback: How may the Workshop be improved?

Some of the participants felt that the workshop would have benefited from focused topic seminars given by international experts. In particular this need where industry could be supported was addressed. These points are well taken and could be incorporated in a follow-up workshop where certainly more information from the internet could be funneled into the identified areas. However the organizers felt in a first step the strong need to provide an unbiased environment for the group in order to be able to work from a pristine platform where nano can make a contribution in the quest to create a new generation of materials, devices and systems that will spectacularly outperform those that we have today in information technology, medicine, environmental technologies, water and food concerns, the energy industry and beyond. However, organizers and participants converged to the conclusion that rapidly obtaining answers to the questions which arise from the discussion groups, would tremendously improve the quality of the analysis. All agreed that faster internet access and a multitude of telephone lines to experts which are prepared to answer questions would be an optimum to expand the format of a future workshop.

Concluding remarks

Not the collection of a comprehensive list of global challenges and their solutions by nanotechnology was the scope of this short meeting. This group was much too small and the time allocated much too short for a profound analysis. It was rather intended to make a snapshot of the current view through the eyes of our next generation of scientists and to provoke a sharpened global perception. The discussions in this multicultural group with high ethnic diversity acted as eye opener for everyone and increased the awareness of the young scientists for the problems and their potential contribution. If the first cooperation projects that were triggered with the scope to address these challenges in consorted efforts will be the seed for the formation of a vibrant network amongst the most brilliant young minds of our planet, the organizers of this workshop will do their best to make this effort a sustainable endeavor, with an option for repetition and expansion. This report will therefore be made available to the global decision makers with the intent to inform them on the young scientists' view of the situation and their potential solutions.



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