

National Research Programme Portrait (NRP 64)

Opportunities and Risks of Nanomaterials



SWISS NATIONAL SCIENCE FOUNDATION

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What is an NRP?

National Research Programmes (NRP) provide scientifically substantiated solutions to urgent problems of national significance. They are approved by the Federal Council, last from 4 to 5 years and are funded with CHF 5 to 20 million. NRPs are problem-oriented; inter- and transdisciplinary; dedicated to achieving a defined, overall goal through coordination of individual research projects and groups and focused on the knowledge transfer of the results.

More information: www.nrp64.ch
You can order the electronic newsletter via the website.

Nanomaterials: seize opportunities – minimise risks

National Research Programme 64 «Opportunities and risks of nanomaterials» (NRP 64) identifies and promotes areas where research is needed in order to better understand the major opportunities and possible risks posed by products based on engineered nanoparticles. The planned research projects will help to solve problems and answer questions related to such particles. The research carried out under this programme will provide a scientific basis for recommendations and appropriate measures with regard to the generation, use and disposal of engineered nanoparticles. The insights gained from the study of engineered nanoparticles and their applications will benefit society at large and help to protect the consumer and the environment.

Nanotechnology – one of the key technologies of the 21st century – comprises design, characterisation, production and application of materials and systems whose size and form are in the nanometre range. Nanoparticles are minute particles that have at least one dimension at the nanoscale level, typically ≤ 100 nanometres. They can be generated by nanotechnological processes and are an important element of nanotechnology. Their physico-chemical properties are radically different to those of larger particles of the same material as their surface is significantly larger relative to their volume and they are thus more prone to chemical reactions. Furthermore, nanoparticles can penetrate small



Prof. Dr. Peter Gehr

spaces that are not accessible to larger materials. While these properties enable new types of use, engineered nanoparticles could also have harmful effects that we are only beginning to understand.

The research projects of NRP 64 take account of the fact that nanomaterials may interact differently with biological systems than materials composed of larger particles. The crucial factors in this respect are the small size of the nanoparticles, their high reactivity in correlation with their smallness and relatively large surface, and their chemical composition. Modern, innovative methods and new models are needed to study their biological effects.

The 18 research projects of NRP 64 examine the opportunities and risks emanating from nanomaterials at

different stages in their life cycle. Most of the projects are concerned with ascertaining the use of nanomaterials in environmental applications and examining their behaviour, whereabouts and impacts on humans and the environment. The majority of projects that emerged from the two-tier evaluation procedure revolve around medical and environmental applications.

Switzerland plays a key role in nanosciences and research into nanomaterials. NRP 64 aims to strengthen the Swiss position, thus creating advantages for Swiss business and industry as well as for the labour market. At the same time, Switzerland is to maintain its leading role with regard to risk assessment and official regulations. In the best traditions of Swiss research, the NRP 64 projects will adopt modern methods and a networked

approach in fulfilling the title of the programme: to seize opportunities and minimise risks.



Prof. Peter Gehr

President of the Steering Committee of NRP 64,
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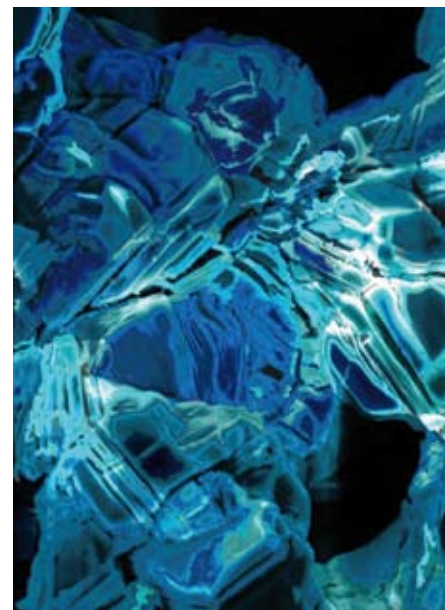
Close-up of a key technology

Nanoparticles are the building blocks of one of the key technologies of the 21st century. While the size of these structures is growing smaller, their importance is growing bigger in both technological and economic terms. Nanoparticles are in the process of revolutionising technological applications from industry through to medicine. Despite their enormous potential, the fabrication, use and disposal of nanomaterials can pose a threat to humans and the environment. NRP 64 closely examines the opportunities and risks of nanomaterials and establishes the basis for their profitable and safe exploitation.

Tiny robots that transport drugs directly and without side-effects to the diseased tissue, or implants – as light as plastic and as hard as steel – could transform medicine in the near future. The stuff of which these dreams are made is extremely small. But the hopes of the world are pinned on it.

How small can you get?

The field generally referred to as «nanotechnology» deals with particles and structures that are smaller than the ten-thousandth part of a millimetre. That is smaller than one eight-hundredth of the diameter of a hair. Or in other words: imagine a football in relation to the terrestrial sphere; a nanoparticle is just as small in relation to the football.



Omnipresent nanos

These minute particles open the doors for a wide range of applications – for instance in medicine, energy technology and environmental technology, data storage, the chemical industry, the production of new materials, and the food and consumer products sector.

Nanotechnology is thus a true crossover technology that promises improvements in all areas of life. Numerous materials, such as metals, metal oxides, carbon modifications and pigments contain nanoscale structures. When further processed, they often lend the resultant materials new – often radically improved – properties, such as scratch-proofness or depth of colour. They thus facilitate the development of intelligent and highly effective product innovations, the type that are studied in NRP 62 «Smart

Materials». Technologies based on nanomaterials also hold the promise of significant improvements in the health and environment sector.

Responsible risk research

Every bright light casts a shadow. The potential of the new technologies should not make us blind to the risks they may carry. Despite rapid progress in the development of nanomaterials and an increasing number of nano-based products on the market, little is known about how exposure to such materials affects humans and the environment. A lot has been invested into research on technical applications, but little into examining the potential risks. NRP 64 «Opportunities and risks of nanomaterials» helps to fill this knowledge gap by identifying the most significant opportunities and assessing the potential

dangers for human beings and the environment.

Fields of application

Sectors	Economic potential	Product groups
Automotive manufacturing	Economic potential	Ultraflat surfaces
Automotive engineering		Laquers
Building and construction		Ultra-thin layers
Chemical industry		Semiconductors
Electronics		Lasers
Energy technology		Storage
Information technology		Ceramics
Machinery and plant construction		Liquids
Medicine		Polymers
Measurement and control technology		Agents
Optics		Solar and fuel cells
Pharmaceutics		Ultra-precision machines
Environmental and food technology		Scanning probe systems
Tool engineering		Scanning electron microscope

Research objectives

NRP 64 aims to identify opportunities arising from the use of nanomaterials for health care, the environment and natural resources. At the same time, it intends to reveal the potential risks that nanomaterials pose in these areas.

NRP 64 specifically aims to:

- gain insights into engineered nanomaterials, their development, use, behaviour and risks;
- develop methods and tools to monitor the behaviour of nanomaterials and their potential effects on humans and the environment;
- develop tools that maximise the advantages of nanomaterials and minimise the risks for humans and the environment;
- support the development and application of safe and effective technologies based on nanomaterials;
- make information available for decision-makers, including manufacturers, distributors and consumers;
- enhance and strengthen specialist knowledge and competencies for developing innovative nanomaterials and assessing risk in Switzerland.

Structure of the programme

NRP 64 has been assigned a budget of CHF 12 million. The 18 approved projects were proposed by research groups from Berne, Fribourg, Lausanne, St. Gallen and Zurich. They can be roughly divided into the research modules Biomedical research, Environmental research and Other research domains. It is planned to launch a second call at the end of 2011 in order to close any research gaps – for instance with regard to foodstuffs and consumer products or building materials – and address further key issues, such as long-term effects, toxicokinetics and organ toxicity.

Biomedical research module

The biomedical module deals with the potential health effects of the use of nanomaterials. New nanomaterials can indeed lead to pioneering developments in pharmacology, medical testing and medical equipment. Synthetic medicines based on nanoparticles open the doors for a new generation of multifunctional

drugs. They combine the properties of conventional agents with those of diagnostic and therapeutic devices. This approach involves transporting small doses of active agents directly to the desired part of the body, thus creating a stronger therapeutic effect without side-effects. A further area of application are implants or bone-substitute materi-

als, whose mechanical and immunological properties can be optimised through nanoparticles. In this context, nanoparticles can enter the body, stay there or be released through interactions, which can in turn cause unintended effects besides those that are intended. The nine projects of the biomedical module thus need to develop toxicity tests and innovative approaches for assessing risks.

Environmental research module

The projects of the environmental research module assess the effects of nanoparticles on the environment and on ecological systems. Nanoparticles can be released into the water, air or earth either deliberately – for instance when plant protection products are used in farming – or unintentionally in

the course of manufacturing, use or disposal. Although nanoscale particles also occur naturally, it is not yet possible to definitively assess the ecological impacts of engineered nanomaterials that enter the environment. The transformation of nanomaterials during their life cycle, including their generation and breakdown and their interactions with environmental substances, make it difficult to assess and control the potential effects. This module intends to bring greater clarity in this area.

Other research domains module

This module contains two projects examining the development and use of innovative nanomaterials, nanocomposites and innovative building materials. In addition, they evaluate the potential health hazards and environmental risks associated with these materials throughout their life cycle. In the future, further projects can be added to this module. Areas of main interest are the use of nanomaterials in food and consumer products as well as long-term effects, toxicokinetics or organ toxicity.





Projects in Biomedical research

Carbon coated nanomagnets and their in vivo lifecycle

Prof. Beatrice Beck Schimmer
Institute of Anesthesiology,
University Hospital Zurich

Carbon coated nanomagnets have the property to bind molecules and therefore also drugs particularly efficiently to their surface. They can be guided magnetically and thus directed to specific areas of the body. Using cellular and in vivo models, the research team explores how well carbon coated nanomagnets can be guided in tissue, how many particles remain in the blood stream and to what extent medication and inflammation mediators can be eliminated from the blood stream

using magnetic separation. As the knowledge of potential risks of carbon coated nanomagnets is currently rudimentary, the study will also look at the particles' compatibility, interaction, accumulation and toxicity in blood vessels and organs (e.g. in endothelial, blood and liver cells).

Novel nanoparticles for efficient and safe drug delivery

Prof. Francesco Stellacci

Supramolecular Nanomaterials and Interfaces Laboratory, EPF Lausanne
(in collaboration with MIT Cambridge and Ann Arbor Michigan, USA / IIT Lecce, Italy)

Viruses are able to introduce genetic material into targeted cells to influence their functions. Modern nanomedicine is trying to imitate this mechanism (e.g. cancer treatment).

The project aims to develop engineered analogues to viruses which are able to deliver drugs and genetic material precisely and with minimal risk to targeted cells without triggering strong immunotoxic and cytotoxic reactions. The metallic nanoparticles with organic molecule coating will be able to introduce agents into the cell without damaging the

membrane. The results will add to the theoretical and practical knowledge regarding the mechanisms of cell penetration and the nature of bio-compatible nano-vehicles which can target particular areas of a living organism.

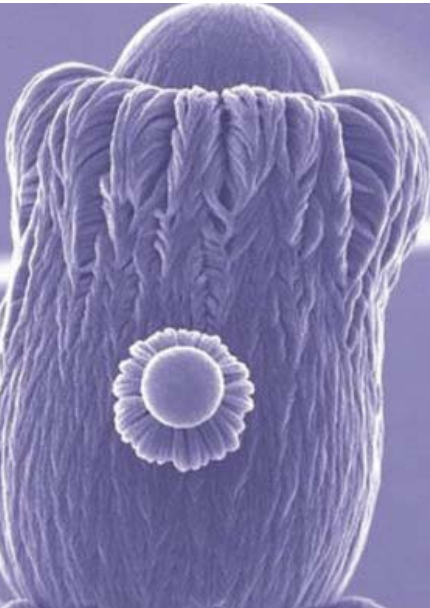
Nanoparticle transport across the human placenta

Dr. Peter Wick

Materials Biology Interaction, Empa St. Gallen

Although humans have been exposed to a multitude of particles throughout their history, nanotechnology is producing novel engineered particles with little known effects. Over the last few years, there has been growing concern that nanoparticles, such as are present in polluted air, could adversely affect

foetuses. Today we know that particles of up to 200 – 300 nm in diameter can pass from the mother's into the baby's blood inside the human placenta. However, we do not know how the particles pass the placental barrier and what effect the particles have on the unborn child. The project explores the mechanism of particle transport and possible effects in the placental tissue by using a placenta model. The work will contribute to new strategies for administering drugs during pregnancy, which will make it possible to treat only the mother if the child does not need treatment.



Risk analysis of inhaled nano particles by in vitro technology

PD Dr. Marianne Geiser Kamber
Institute of Anatomy, University of Berne

The inhalation of engineered nanoparticles in powders, dispersions or sprays set free in industrial production or usage of consumer goods poses risks. Persons with lung diseases, children and the elderly are particularly at risk. The research team analyses the effects of inhaled nanoparticles on healthy and diseased lung tissue. They use a novel, portable and realistic test system with cell cultures which replicates the lung surface and allows them to observe infectious mechanisms and processes. The versatile system can be used for a variety of particles and cell cultures from various particle sources and it makes realistic in vitro toxicity testing possible.

Analysis and fate of nanoparticles in the lung and expected biological effects

PD Dr. Michael Riediker
Institute for Work and Health IST,
University of Lausanne

Precise information about the inhalation and fate of nanoparticles in the lung is needed before new therapeutic applications can be developed. Due to their small size, nanoparticles are able to penetrate living cells. Due to their large surface area they have increased reactivity, which may pose a health risk. It is assumed that inhaled and deposited nanoparticles become suspended in the lung lining fluid and subsequently translocate to the bloodstream. Another theory suggests that only reactive particles cause oxidative stress in the lung lining fluid followed by an increase in the corresponding markers in blood

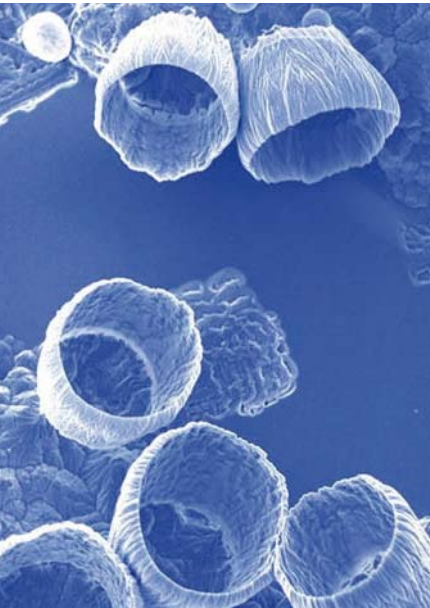
and urine. These two hypotheses will be tested as follows: fluorescent superparamagnetic iron oxides (PVA_SPIOs) will be inhaled and their deposition and translocation into the bloodstream will be quantified. Subsequently, exhaled air, blood and urine will be analysed. The procedure will be repeated with smokers to prove the marked difference between the two groups. The results of this project will create the basis for an improved risk analysis of health implications caused by inhaled nanoparticles.

Nanoparticles in biodegradable implants: distribution and effects in brain tissue

Prof. Martin Frenz
Institute of Applied Physics,
University of Berne

Nanoparticles are increasingly used in medical applications such as diagnosis, drug delivery and degradable implants. If they enter the bloodstream they can be transported into the brain and by passing the blood-brain-barrier they can enter the cells of brain tissue. If the nanoparticles interact with the cells, they can cause oxidative stress or affect protein synthesis. The research group wants to show how nanoparticles spread throughout the organism via the bloodstream and establish if they cause unwanted cellular reactions in the brain. In a further step they will analyse the interactions of

engineered nanoparticles with cells and organelles. With optical and electron microscopes they hope to show that the distribution of nanoparticles in cells and marked particles will help to map the distribution of particles in the organism as a whole.



Nanopharmaceuticals against chronic inflammatory bowel disease

Dr. Caroline Maake

Institute of Anatomy, University of Zurich

The current therapy for chronic inflammatory bowel diseases, such as Crohn's Disease, are often insufficient and have severe side effects.

Collaboratively, scientists involved in basic research, medical doctors and quality management specialists are trying to establish in the laboratory whether the feared side effects of established medication can be eliminated by limiting their biological activity to the affected bowel area and minimising exposure of the rest of the body. The idea is to "wrap" highly concentrated medication in newly developed biodegradable nanoparticles. The medication would thus be released and activated

only in the affected bowel segment. The project combines innovative developments in nanotechnology with tested clinical therapy concepts and aims to create a basis for improving the quality of life of sufferers.

Biomimetic nanofibre reinforced bone substitute composites

Dr. Reto Luginbuehl

RMS Foundation Bettlach

Nanofibres can reinforce bone substitute materials and successfully mimic the bone's mechanical properties. This opens up new surgical possibilities with plates, screws and types of cement. While it is recognised that nanofibres offer great potential, the biological effects on cells, tissue and organs are not fully understood.

The project team will develop reabsorbable nanofibres based on calcium phosphates and observe reactions to the fibres in cells and tissue. They will create, test and biologically characterise engineered nano composite materials in cell and animal models. The composites with the best properties will be analysed in more depth regarding inflammatory processes, bone healing, osseointegration and, in particular, distribution of the nanofibres through the organism.

Biomedical nanoparticles as immune-modulators

[Dr. Barbara Rothen-Rutishauser](#)
[Institute of Anatomy, University of Berne](#)

Lung allergies such as allergy induced bronchial asthma are on the rise worldwide. Nanoparticles have both immunostimulatory and immunosuppressive effects and are therefore of particular interest in clinical diagnostic applications and allergy therapy. They are specifically suited to administering medication and vaccines. The project aims to analyse the immunomodulatory effects of therapeutic nanoparticles in the lung. Specifically designed nanoparticles will be tested in cell culture systems (in vitro) and in allergic mouse models (in vivo) with special emphasis on their influence on innate and acquired immunity as well as on possible nano-immuno toxicity in

the lung. The results of this multidisciplinary approach will contribute to the development of new therapeutic applications for lung diseases and help identify possible negative effects of therapeutic nanoparticles.

Projects in Environmental research

Modelling of nanomaterials in the environment

PD Dr. Bernd Nowack
Technology and Society, Empa St. Gallen

Nanomaterials are contained in many consumer products and can reach the environment from there. No analytical methods are currently available to quantify trace concentrations of nanomaterials. The research group aims to assess current and future threats to the environment by studying material flows and the environmental behaviour of nanomaterials. Based on information on the production and use of nanomaterials, the researchers will form an estimate of the amounts released by individual

applications. Subsequently, they will model the processes governing the behaviour of these materials in water, sediments, soils and air. The results will give an indication of nanomaterial concentrations in different environmental media. Together with data from ecotoxicological studies, this will enable the researchers to estimate whether certain nanomaterials pose a risk to the environment.

Silver nanoparticle effects at the food web and ecosystem level

Dr. Renata Behra
Environmental Toxicology, Eawag Dübendorf

Nanosilver is one of the most used materials in commercial and medical products. While its antimicrobial properties are useful in many applications, they also harbour potential risks for the environment and, in particular, for ecosystems dominated by microorganisms. The project team studies the effects of nanosilver on microbial decomposers that degrade plant litter and on submerged autotrophic biofilms. Both systems produce substantial amounts of biomass that are passed on to the ecosystem through the food web. The results of the study will provide a sound basis for regulations on the responsible use of nanosilver.

Behaviour of silver nanoparticles in a wastewater treatment plant

Dr. Ralf Kaegi

Process Engineering, Eawag Dübendorf

Silver nanoparticles are increasingly used as biocides in a wide range of products. Through sewer systems they reach wastewater treatment plants, which play a key role in their dissemination. This project studies the physical and chemical changes occurring in nanosilver during different stages of the wastewater treatment. Depending on its physico-chemical properties, nanosilver may flow through the wastewater treatment plant and into the surface water. If sequestered with the sewage sludge, it enters the soil when the sludge is recycled. In particular, the researchers wish to ascertain how particle size and surface structure influence the level

of retention in the wastewater treatment plant. The results will serve as a basis for the development of nanomaterials with a reduced impact on the environment.



Non-invasive continuous monitoring of the interaction between nanoparticles and aquatic microorganisms

Prof. Olivier Martin

Nanophotonics and Metrology Laboratory,
EPF Lausanne

The data available on the toxicity of released nanoparticles is limited and rather controversial. Furthermore, there is a lack of instruments to measure ecological risks, particularly for microorganisms in the water. It is known that oxidative stress is an indicator of the effects caused by nanoparticles on single cell aquatic organisms. The multidisciplinary project aims to develop a biosensing platform which can measure in real time and in parallel several biomarkers for oxidative stress. The approach is based on measurements of the absorption peak of the cytochrome C protein by

means of plasmonic nanoantennas. The platform makes it possible to measure non-invasively the effects of engineered nanoparticles on aquatic microorganisms and it contributes to an in-depth understanding of ecotoxic processes.

Interaction of metallic nanoparticles with aquatic organisms

Prof. Kristin Schirmer

Environmental Toxicology, Eawag Dübendorf

With the aim of expanding our knowledge regarding the effect of nanoparticles on aquatic environments, the project analyses the interactions of metal nanoparticles with aquatic organisms. Focusing on algae and fish cells, the researchers are exploring the uptake, elimination, intercellular transformations and interaction with biological systems. The knowledge gained will form the basis of guidelines to optimise the design of metal nanoparticles and it will be influential in assessing risk and regulating the production, application and disposal of nanomaterials.

Effects of nanoparticles on soil microbes and crops

Dr. Thomas Bucheli
Research Institute Agroscope,
Reckenholz-Tänikon ART, Zurich

Nanoparticles in plant protection products and fertilisers may lessen the use and impact of pesticides and fertilisers in the environment and may increase crop productivity. The research team is analysing the risks of nanoparticles in agricultural applications. Specifically, it will test the accumulation of nanoparticles in soil, soil microbes and crops to better understand if they affect microbial population structures and key ecological functions performed by symbiotic soil microbes. There is a focus on nitrogen fixation and phosphorus acquisition. Crops (wheat and clover) and microorganisms (bacteria and fungi) will be tested

in systems of increasing complexity: from laboratory cultures over controlled pot experiments with sterile soils to lysimeter studies with real soils. The study will provide relevant ecotoxicological information on exposure and effects of nanoparticles as a basis for a comprehensive risk assessment.

Biodegradation of carbon-based nanomaterials

Dr. Hans-Peter Kohler
Environmental Microbiology,
Eawag Dübendorf

The Eawag research team will examine the environmental behaviour of carbon-based nanomaterials, such as fullerenes and carbon nanotubes. Although wastewater effluents in different countries

already contain fullerenes, the biogeochemical degradation of this nanomaterial has not been extensively studied until now. The team will investigate whether enzymatic, cellular or microbial systems are able to degrade or transform carbon-based nanomaterials and what the individual transformation products are. The results will serve as a basis for risk assessment and allow regulatory bodies and political authorities to make decisions and recommendations regarding its use. The project will also generate biotechnological knowledge for the development of functionalised carbon-based nanomaterials, which would open up a new research field for supramolecular nanosystems.

Projects in Other research domains

Cellulose-based nanocomposite building materials

Prof. Christoph Weder
Research Centre for Nanosciences,
University of Fribourg

The building sector is increasingly interested in high-performance nanocomposites made from engineered polymers and cellulose nanofibres made from renewable sources. The research project follows the development of these materials, which are based on two design approaches: on the one hand, light building material with properties comparable to steel, on the other hand porous nanocomposites as an alternative to conventional foamed insulation

material. At the same time, a recently established in vitro cell model based on epithelial cells of the human lung will be used to analyse the possible toxicity of cellulose nanofibres and potential risks across the life cycle of the desired materials. The great interest in building materials based on cellulose nanocomposites and their imminent commercialisation means that the results of this project are of high practical significance.

Evaluation platform for safety and environmental risks of CNT reinforced nanocomposites

Dr. Bryan Chu
Functional Polymers,
Empa Dübendorf

The mechanical and electrical properties of composites reinforced with carbon nanotubes (CNT) allow for industrial applications. They can already be produced industrially and some are available on the market. There is, however, insufficient knowledge regarding the risk potential of these materials in research, production, machining and disposal. In interdisciplinary collaboration, the project develops a method to simulate nanoparticle emission during production and machining as well as in the case of material fracturing. This allows for an assessment of the risks involved for

humans and the environment. The approach will establish a standard for assessing the health risks of nanocomposites.



Increasing knowledge to enhance opportunities and risks dialogue

Knowledge transfer enables researchers to build a network. Through a kick-off meeting and annual scientific meetings, exchanges on research progress and possible areas of complementarities between projects are ensured.

In the field of nanomaterials, alongside information exchanges between the programme's research groups, it is particularly important to examine the international context and promote networking via conferences and research programmes. The Head of Knowledge Transfer assists the researchers in communicating their research results outside the bounds of the programme. He also assures coordination with the Action Plan and the Precautionary Matrix for Synthetic Nanomaterials of the Swiss Federal Office of Public Health.

Cooperation with researchers

NRP 64 will run a Summer School in 2012 and 2013 with a view to promoting junior scientists. The Summer Schools will allow nanomaterials researchers to talk about themselves and their work. The participants will also learn useful new working methods and tools. Regular site visits are planned to discuss individual projects with the project leaders, and identify those elements that are of interest to the public. Strategies will be jointly developed to communicate research topics and results. The final

phase of the programme will feature symposiums where researchers will explain their work and present their results to different organisations, groups, public authorities, representatives from industry and individuals. The ensuing political and public discussions can be regarded as concrete results of knowledge transfer.

Issues Management

The public interest in this socially significant field is reflected in the media debate on the risks and opportunities

of nanomaterials, which flares up intermittently. Aiming to register changes in public opinion as early as possible, the NRP has developed an issues management system which systematically monitors key issues. It discusses these issues with various stakeholders and, if necessary, organises appropriate communication measures.

Regulation needed

The project results should serve as a basis for government regulations and guidelines for the manufacture of nanomaterials-based products. While it is important to keep an eye on production, the product must also be monitored across its entire life cycle. Until the government regulations are finalised, the industrial sector must assume a certain degree of self-regulation and perform risk assessments on the pro-

ducts it manufactures. Calling for caution in the use of innovative nanomaterials till more is known about their effects involves continual discussions with various regulatory, political and industrial target groups. The aim is to give the consumer the highest possible degree of certitude regarding the safety of products based on nanomaterials. Another prime objective is to increase public awareness of the opportunities that nanomaterials hold in store in biomedical and climate research as well as in other areas.



Key terms

Autotrophic Refers to the mode of nutrition of organisms that need only inorganic matter to build up their body substance. Green plants, algae and some bacteria are autotrophic organisms.

Biocompatible Characteristic of a compound that has no negative effects on the tissue of living organisms, e.g. implants or prostheses.

Biomimetic Characteristic of a compound that imitates biological structures or processes.

Biocide Agent that biologically or chemically destroys, deters or neutralises pests such as moths, rats, fungi etc.

Carbon nanotubes (CNT) «Extended» nanotubes, i.e. carbon atoms rolled cylindrically and arranged in hexagons. Carbon nanotubes are 50 times more resistant to pull and much lighter than steel. They can be insulating, semi-conducting or metallic.

Cytotoxic Poisonous, damaging to cells.

Deposition Sedimentation.

Endothelial cells Cells that line the interior surface of lymph vessels and blood vessels.

Epithelial cells Cells that line almost all of the inner and outer surfaces of the bodies of humans and animals in continuous single- or multilayered sheets, e.g. skin.

Fullerenes Ball-shaped molecules composed entirely of carbon atoms, synthesised for the first time in 1985. They are used, e.g., in the manufacture of sports equipment and they make possible lighter and more durable products.

Heterotrophic Refers to the mode of nutrition of organisms that require carbon from organic compounds to build up their body substance. Humans, animals, fungi and most bacteria are heterotrophic organisms.

Immunotoxic Poisonous or damaging to the immune system.

Metabolites Refers to all products that occur in biological metabolisms.

Nanocomposite (NCM) Association of different materials that contain, among others, nanoscale particles and structures. Such associations improve the properties of the material.

Nanometre (nm) Measure of length, refers to the billionth part of a metre (10^{-9} metres) and corresponds to approximately 5 to 15 atoms side by side.

Nanoparticle (NP) Tiny particles measuring 100 nanometres or less. Their chemical and physical properties are different to those of larger particles of the same material, they have a much larger surface relative to their volume and therefore greater reactivity. Some nanoparticles occur naturally, others are engineered.

Organelle Element of a cell that is lined with a membrane and carries out a specific function for the cell, e.g. mitochondria.

Oxidative stress Within a cell, state produced by the imbalance between highly reactive molecules, so-called free oxygen radicals, and the cell's defense mechanisms. Oxidative stress damages the cell, causing malfunctions and ultimately leading to cell death.

Reactivity Ability of a substance to start a chemical reaction.

Toxicity The degree to which a substance is poisonous.

Translocation Transfer process from one location to another.

Duration of the programme

The research projects of NRP 64 have a running time of five years (up to the end of 2015).

The final reports will be published in 2016 and presented at a series of events.

Milestones

December 2010	Start of research
March 2011	Kick-off meeting for researchers
Summer 2011	Publication of Second call for further research projects
December 2011	Submission of research projects
Summer 2012	Summer School NRP 64
July 2012	Start of new research projects (Second call)
December 2013	Start of follow-up projects
End of 2015	Conclusion of research work
2016	Wrap-up tasks, events and publication of final reports

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The Swiss National Science Foundation

The Swiss National Science Foundation (SNSF) is Switzerland's leading provider of scientific research funding. Commissioned by the federal government, it supports research work in all academic fields, from philosophy and nanoscience to biology and medicine. The focus of its activities is the scientific endorsement of projects submitted by researchers.

Yearly, approximately 3000 projects including around 7000 scientists are funded by the SNSF with an annual total amount of approximately CHF 700 million.

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The NRP 64 in brief

NRP 64 is a research programme studying the opportunities and risks presented by nanomaterials. It has a budget of 12 million Swiss francs and lasts until October 2016. A total of 18 research groups from Berne, Fribourg, Lausanne, St. Gallen and Zurich are participating in the programme.

The NRP 64 aims to

- gain insights into engineered nanomaterials, their development, use, behaviour and risks;
- develop methods and tools to monitor the behaviour of nanomaterials and their potential effects on human beings and the environment;
- develop tools that maximise the advantages of nanomaterials and minimise the risks for human beings and the environment;
- support the development and application of safe and effective technologies based on nanomaterials;
- make information available for decision-makers, including manufacturers, distributors and consumers;
- improve and strengthen specialist knowledge and competencies for developing innovative nanomaterials and assessing risk in Switzerland.