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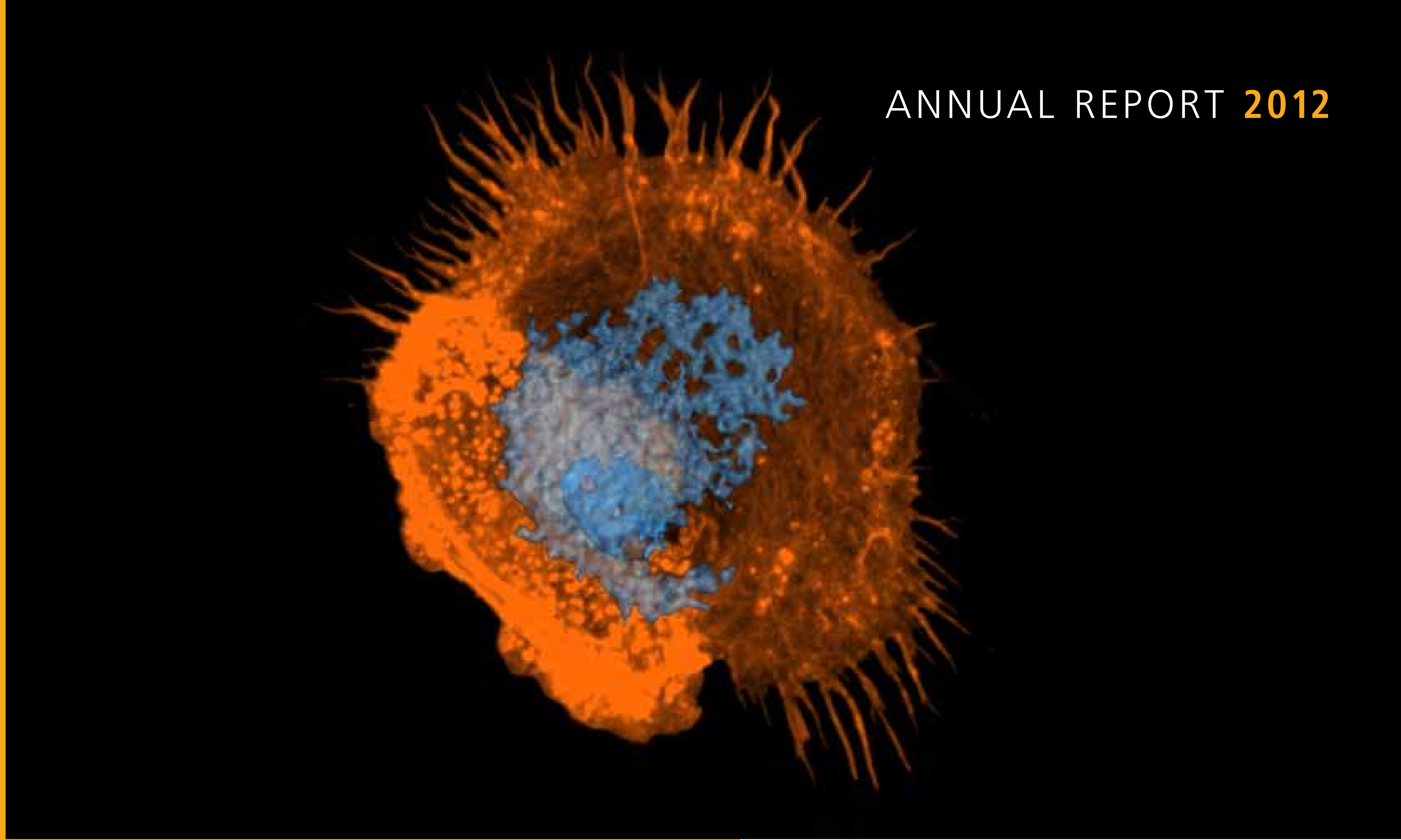
ANNUAL REPORT 2012



adolphe merkle institute
excellence in pure and applied nanoscience

UNIVERSITY OF FRIBOURG SWITZERLAND

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Message from the director

Christoph Weder
Director and Professor for Polymer Chemistry and Materials

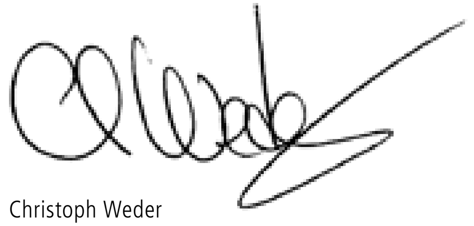
Looking back at the last year at our institute I am asking myself if I should write about a year of continued growth or a period of consolidation. The mere numbers evidence substantial growth over the previous year in personnel (+34 %), research expenditures (+27 %), and research output – the number of papers published increased by 19 % and we filed our first couple of patents. We also added junior research groups for Nanoparticles Self-Assembly and Soft Matter Scattering, led by Prof. Marco Lattuada and Dr. Sandor Balog, respectively. On the other hand, by the end of the year, our existing research groups had approached sizes, that I think are close to a steady-state, and I believe that our overall indicators will remain pretty stable before we add two additional chairs in 2014 and 2015 to complete our team.

Perhaps more important than the growth reflected by the above indicators is the less tangible observation that the individual groups have begun to interact on many different levels, grow together as a team, and instill AMI with a distinct and intriguing ambiance. Our PhD students, postdocs, senior researchers, and professors not only see each other in the laboratories, offices, and meeting rooms, but also meet for social events like our weekly Friday Cake, occasional outings such as our annual ski day, or excursions such as the recent one to CERN. Of course, conversations in these settings do not always focus on science, but I wager the claim that these less formal encounters of individuals that come from the fields of chemistry, biology, materials science, and physics contribute significantly towards achieving our most important goal: to nucleate research programs at the interface between disciplines.

The development, investigation, and use of bio-inspired soft nanomaterials and the study of the interactions of such materials with biological systems have precipitated as themes that have become a rallying point of the four AMI groups and certainly represent areas of research where interdisciplinary interactions are not a luxury, but a requirement for success. It will take a while until the emerging interactions will fully bear fruits, but I hope that the developments and achievements documented in this annual report will be good indicators of our institute's future.

The various accounts in this report are also meant to document that the integration process goes beyond the internal landscape. Partnerships with peers at Fribourg's School of Business Administration, the Fribourg College of Engineering and Architecture, and several Departments of the University of Fribourg's Faculty of Natural Sciences have led to a range of inter-institutional projects that revolve around interdisciplinary research and development, educational ventures, and mechanisms to foster innovation.

At AMI, we recognize the value of partnerships and are once again grateful for the interest, courtesy, and support that we received throughout the year. We will continue to work hard to realize Adolphe Merkle's vision of becoming a leading competence center for fundamental and applied interdisciplinary research in the field of soft nanomaterials, be a valuable and reliable partner, and to make relevant contributions to science and society.



Christoph Weder
Director and Professor for Polymer Chemistry and Materials


AMI in 2012

After a rapid growth over the last 18 months to its current size of over 60 employees, AMI has completed a first development phase and is now consolidating its activities around the two chairs in Polymer Chemistry & Materials and BioNanomaterials and two smaller research groups that focus on Self-Assembly and Soft Matter Scattering. A culture of multidisciplinary collaborative research has been developed and the research programs of the individual groups are beginning to merge. Another growth phase, which will involve the addition of two additional chairs, will be initiated in 2014, when the institute will move to its new building.

Prof. Marco Lattuada (left) and Dr. Sandor Balog (right).

Building on Adolphe Merkle's legacy

After mourning the loss of AMI's co-founder and patron, Dr. Dr. h. c. Adolphe Merkle, in February 2012, the AMI community has continued to implement his vision of building a leading-edge research institute focused on soft nanomaterials. Dr. Merkle's generosity, foresight, dedication, and extraordinary drive remain a source of inspiration that continues to forge an entrepreneurial spirit. This is certainly one of the most valuable virtues of the institute that he created.

New Self-Assembly Group

Professor Marco Lattuada from the ETH Zurich joined AMI in 2012 to build a junior group focused on nanoparticles self-assembly. He was awarded with a prestigious SNF-Professorship grant (1.5 Mio. CHF) and chose to pursue his research at AMI for the next four years. The research activity of his group is devoted to the rational design and the synthesis of nanoparticles and to the investigation of their self-assembly behavior. He uses a balanced combination of experiments and simulations, with the objective of creating new materials with tailored properties. AMI is proud to host this experienced nanoscience expert and his research team, which currently consists of one post-doctoral researcher and three PhD students.

New Soft Matter Scattering Group

To expand the knowledge base and support in the field of scattering techniques, which are key methods when working with soft nanomaterials, Dr. Sandor Balog joined AMI in June 2012. He is a Senior Researcher with interest and expertise in the physics of soft nanomaterials. Dr. Balog obtained his PhD in physics from the University of Fribourg and has since then worked at the EPFL and at the Paul Scherrer Institute, where he developed a research line concentrating on X-ray and neutron scattering of ion-containing polymers. His research focuses on the structure and morphology of synthetic and natural soft nanomaterials, and he aims to understand how these fundamental characteristics govern their behavior and functionality when interacting with their environment.

Visit of the Scientific Advisory Board

For the third time since the foundation of the institute, AMI's Scientific Advisory Board visited the institute, interacted with researchers, institute leadership, and institute council, and assessed the activities and plans for the future. The board acknowledged the institute's impressive development in both quantitative and qualitative terms, the commitment and enthusiasm on all levels, the very successful integration of new research groups, the impressive level of third party funding, the overall quality of the ongoing research programs, and the efficient and professional support structure of the institute. The board also provided valuable input for the positioning and future development of the institute.

New interdisciplinary initiatives in Fribourg

The ideal boundary conditions in Fribourg, particularly on the "Plateau de Pérolles", which hosts several research and educational institutions, facilitated multiple inter-institutional projects that emphasize interdisciplinary research and development, educational ventures, and mechanisms to foster innovation. Several joint research projects with groups from the departments of physics, chemistry, and geosciences of the University of Fribourg were launched in 2012. These projects indicate

that AMI's activities are well-aligned with the strategic focus of the faculty on "nanomaterials" and "life science & biomedicine" as described in the strategic plan of the University.

"Thermoplastic polymer nanocomposites" was identified as a specific domain of common interest between AMI and the College of Engineering and Architecture Fribourg. Several collaborative projects that pursue the translation from the lab to industrial scale processes were launched and presented to industry at several occasions (see text box on page 10) . Early in the year, an official delegation of the Canton of Fribourg, which was led by Beat Vonlanthen, Minister of Economic Affairs, and included key representatives of the University of Fribourg, the College of Engineering and Architecture, and AMI, visited the Boston-Cambridge area to explore the elements that contribute to the thriving culture of innovation in bean town and to asses which of those elements could possibly be imported to Fribourg. The delegation visited the Cambridge Innovation Center, the Gateway Park in Worcester, the Wyss Institute for Biologically Inspired Engineering at Harvard, MassChallenge, the Massachusetts Office of International Trade and Investment, and the Fraunhofer Center for Sustainable Energy Systems. Inspired by this visit, the members of the delegation launched an inter-institutional program that aims to promote the entrepreneurial spirit in Fribourg (for more details, see page 32). As a direct result, the already existing collaboration with the School of Business Administration Fribourg was intensified and two Innovation Discovery & Technology Transfer projects, which analyzed the business aspects of AMI technology, were launched as part of the master program in entrepreneurship.

Construction of new building started

After an intense planning phase, the construction of the new buildings on the natural science campus of the University started in early 2012. The re-constructed old parts of two existing buildings and the new laboratory complex will integrate modern state-of-the art infrastructure in a historic context of an ancient clinic and provide a unique working environment for the institute. The prospective move-in date is currently set for spring of 2014.

Computer simulation showing the main entrance of the new institute building and the attached new laboratory building.

Interdisciplinary research projects with partners in Fribourg

- **Chances and risks of nanoscale electrode materials for Li-ion-batteries (National Research Program 64: Opportunities and Risks of Nanomaterials)**
  Synthesis of novel nanoparticulate materials for batteries (Prof. K. Fromm, Chemistry, University of Fribourg) and risk assessment of these materials using a 3D model of the human lung (Prof. B. Rothen-Rutishauser, AMI).
- **Nanotechnology: Implications for the Wood (Preservation) Industry (National Research Program 66: Resource Wood)**
  Synthesis and characterization of ultra small inorganic nanoparticles for wood preservation (Prof. A. Fink, AMI), wood impregnation and wood chemistry (Prof. T. Volkmer, Bern University of Applied sciences), and electron microscopy assisted characterization of impregnated wood samples (Prof. B. Grobety, Geosciences, University of Fribourg).
- **Spatially resolved magneto-relaxation of *in vitro* magnetic nanoparticles using atomic magnetometry (Swiss National Science Foundation Sinergia: platform for inter-, multi- and unidisciplinary projects between different research groups).**
  Production and characterization of functional magnetic nanoparticles and their internalization into macrophages (Prof. A. Fink, AMI), magnetometer development and measurements (Prof. A. Weis, Physics, University of Fribourg), system simulation, data analysis, and source reconstruction (Prof. G. Bison, Paul Scherrer Institute).
- **High Profit Filled Polymers (Pôle Scientifique et Technologique Fribourg, PST-FR)**
  Study of lab-scale cellulose dispersion processes, their influence on materials' properties (Dr. J. Foster and Prof. C. Weder), and scale-up to industrial process (Prof. L. Lalande, Prof. J.- M. Boéchat, College of Engineering and Architecture Fribourg).
- **Scaling of the hydrolysis of cotton based cellulose nanowhiskers (Pôle Scientifique et Technologique Fribourg, PST-FR)**
  Development of a lab-scale hydrolysis method for the production of cellulose nanowhiskers (Dr. J. Foster and Prof. C. Weder) and adaptation of the process for scaling-up to kg batches (Prof. T. Chappuis, College of Engineering and Architecture Fribourg).
- **Application-oriented cell culture assays for the assessment of safe nanomaterials (part of the master program in entrepreneurship, School of Business Administration Fribourg)**
  - Value assessment and analysis of standardization procedures (L. Depraetere, C.-H. Trieu, S. Anougmar, students, School of Business Administration Fribourg). Coaching by Prof. B. Rothen-Rutishauser and Dr. M. Pauchard, AMI.
  - Value assessment and market analysis (M. Boillat, A. Schroeter, students, School of Business Administration Fribourg). Coaching by Prof. B. Rothen-Rutishauser and Dr. M. Pauchard, AMI.

High impact research

AMI has never published more scientific papers than in 2012, when a total of 54 peer-reviewed manuscripts with AMI co-authors were published, including papers in the high impact journals *Chemical Reviews, Advanced Materials,* and *MRS Bulletin,* work that made the covers of the *Journal of Materials Chemistry* and *Advanced Materials,* and research that was highlighted in the journal *Nature.* Researchers from Professor Lattuada's group published an article in *Langmuir* that reports the investigation and use of magnetic fields to control sol-gel phase transitions by the addition of magnetic nanocolloids. An article in *Nanotoxicology* published by researchers from the group of Professors Fink and Rothen-Rutishauser highlighted the necessity of understanding the specific methodology used when assessing the risk of nanomaterials. Professor Weder's team filed three patent applications to protect unpublished inventions in the field of stimuli-responsive polymers.

Continued success in attracting external research funding

More than half of AMI's research expenditures in 2012 were covered by external funding sources, mainly from Swiss government agencies, the European Research Council, and industrial partners. The very high level of competitive funding underlines the interest of external stakeholders in AMI's research programs.

Recognition for AMI researchers

AMI Professor Barbara Rothen-Rutishauser was elected to serve as Associate Editor of *Particle Fibre Toxicology.* She was also featured on the list of most cited anatomists in German-speaking areas. Professor Alke Fink was nominated by the SNF to join the AcademiaNet – Expert Database for Outstanding Female Scientists and Scholars. This initiative, launched by German Chancellor Dr. Angela Merkel in 2010, showcases highly qualified women who have been nominated by recognized research institutions. Professor Christoph Weder continues to serve as Adjunct Professor at Case Western Reserve University in Cleveland (OH, USA) and as a Visiting Professor at Chulalongkorn University in Bangkok, Thailand. Dr. Corinne Jud was selected from several hundred applicants from all over the world to attend the 2012 Novartis International Biotechnology Leadership Camp (BioCamp 2012). This three day seminar brings the biotechnology sector closer to talented students from top universities around the world.

In 2012, AMI researchers delivered a total of 63 presentations at national and international conferences. Particularly noteworthy are the many oral presentations given by PhD students at prestigious international conferences such as the American Chemical Society Meeting in San Diego, USA (Soo-Hyon Lee), the European Nanobio Conference in Varese, Italy (Bastien Schyrr), the Nanosafe Conference in Grenoble, France (Carola Endes), the 9th International Conference on the Scientific and Clinical Applications of Magnetic Carriers in Minneapolis, USA (Cécile Bonnaud), the NN12 conference in Thessaloniki, Greece (Kleanthis Fytianos), and the priority program SPP1313 annual meeting of the German Research Foundation in Fulda, Germany (Vera Hirsch).

Front cover of the November issue of *Magnetic Resonance in Medecine*, featuring an image of AMI's researchers and co-authors


Prof. Marco Lattuada and his team

On the right, Dr. Corinne Jud (AMI), speaking at the 6th International BioCamp at the Novartis Campus in Basel


Prof. Barbara Rothen-Rutishauser giving a talk at the Swiss Nanoconvention 2012 in Lausanne


L'Institut Merkle obtient une bourse de deux millions d'euros

An article on AMI issued in the Swiss newspaper *La Liberté*

Dr. Johan Foster presenting his research at a conference in Switzerland

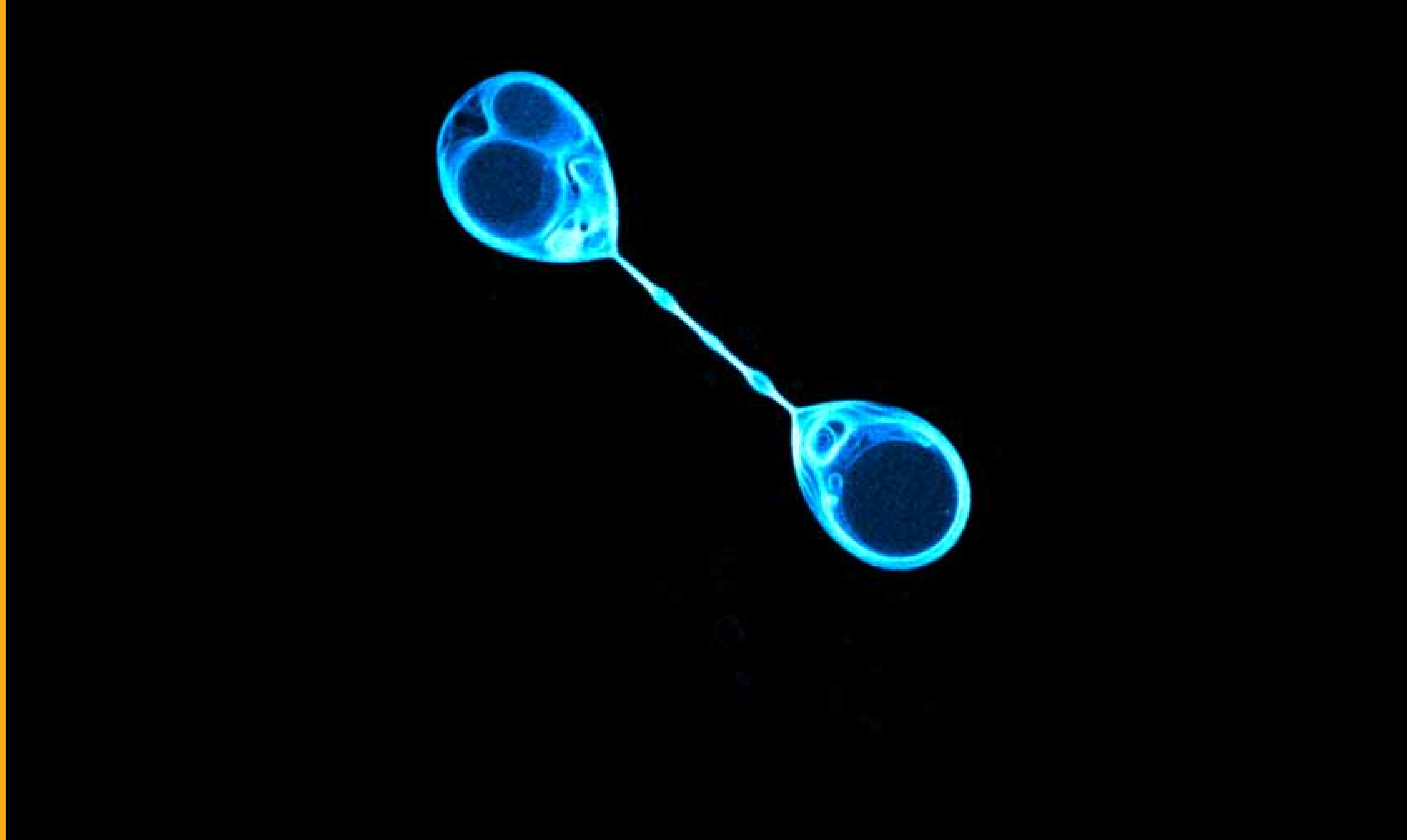
National and international press coverage for AMI

AMI's activities received significant attention from both national and international print media as well as radio and television stations and other electronic media, including *Swiss National Radio DRS, Radio Fribourg,* German (*3-SAT, SWR*) and Swiss Television (*RTS, SF1, La télé*), as well as the newspapers *Freiburger Nachrichten, La Liberté,* and the *St. Galler Tagblatt.* Coverage included the significant growth and development of the institute, research on smart polymers and new treatments for asthma based on aerosol-borne nanoparticles, general aspects on the risks and chances of nanomaterials, Professor Weder's ERC grant, and AMI as one of the first Swiss examples for the "american" model of financing academic research institutes.

Guest researchers and internships

Guest researchers from many different countries visited the institute and joined the individual research groups. Professor Laura Menotti from the University of Bologna, Italy, joined the Bio-Nanomaterial group for six months to improve the efficiency of the systematic virotherapy of cancer. Stephanie Hirn from the Ludwig-Maximillians-University in Munich, Germany, visited the same group for one month in the framework of the national research program "SPP1313" of the German Research Foundation in order to learn specific techniques to label and analyze lung tissue samples. Agueda Sonseca-Olalla from the University of Valencia, Spain, spent several months in the Polymer Chemistry and Materials group to benefit from their expertise in bionano-composite processing and characterization. Several undergraduate students from all over the world, including Florent Gourlaouen from the University of Nantes, Chloé Waeber from EPFL, Marcus Forand from the University of New Hampshire, and Elise Aeby from the University of Basel selected AMI for internships with an average duration of three months.

RESEARCH PROGRAMS



BIOINSPIRATION AS A COMMON PLATFORM

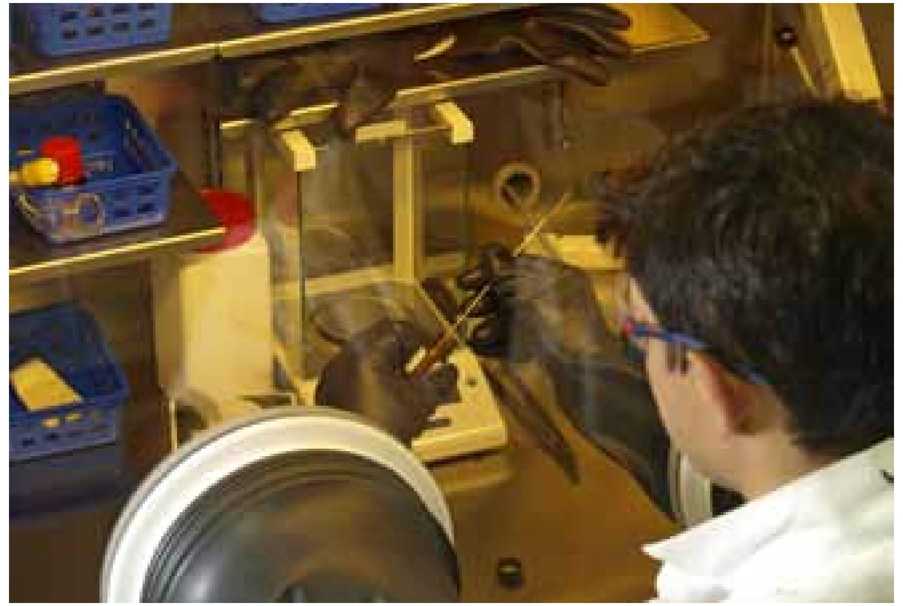
AMI's research activities focus on the development, investigation, and use of soft nanomaterials and the study of the interactions of such materials with biological systems. Specific key areas of interest and focal points of the institute's ongoing research activities are the design of advanced polymers, the development of functional nanoparticles with tailored properties, (self) assembly processes in colloidal systems, and the study of nanomaterial-cell interactions.

By combining the expertise of four research groups in the areas of Polymer Chemistry and Materials, BioNanomaterials, Self-Assembly, and Soft Matter Scattering, AMI scientists have adapted a transdisciplinary research mode that combines chemistry, materials science, soft-matter physics, and biology to tackle important problems that transcend the boundaries of traditional science and engineering disciplines. The creation of stimuli-responsive or "smart" materials, whose properties respond to external stimuli in a predictable and useful manner, and the exploitation of such materials in life science applications, have precipitated as a common research domain of the four groups. Such materials are of fundamental scientific interest and potentially useful in countless applications, for example, self-healing polymer coatings or mechanically adaptive implants.

A broad range of intriguing stimuli-responsive materials exists, but their design and functionality appear crude compared to the complex materials developed by living organisms. To close this gap, AMI scientists are taking inspiration from nature to design advanced materials with stimuli-responsive properties. One overarching goal is to establish new design rules and strategies for the creation of (macro-)molecular and nanomaterial-based stimuli-responsive building blocks and their (self-)assembly into complex, hierarchically ordered responsive structures with new and desirable properties. Given the importance of such advanced materials in life sciences, another principal goal is to develop a predictive understanding of their interactions with living cells and to apply the knowledge generated to much-needed biomedical applications, such as early medical diagnostics, new medical devices, and the treatment of diseases such as allergic asthma. AMI researchers are also carrying out research that aims to better understand the possible risks that might be posed by these new materials. Safe handling and processing of such materials is of particular interest and concern at AMI. However, fundamental understanding of how material properties such as shape, size, and surface impact the interaction with cells is crucial at this stage in order to promote the safe use and development of engineered nanoparticles in the biomedical field.

In 2012, AMI's major research initiatives were:

- The reproducible synthesis and use of functionalized nanoparticles
- The complete control over the surface functionality of anisotropic nanoparticles
- The simulation and experimental investigation of nanoparticle (self-)assembly
- The fabrication and study of nanocomposites with bio-renewable fillers
- The preparation and investigation of mechanically adaptive materials
- The development and investigation of self-healing polymers
- The investigation of metal-containing materials with unusual optical properties
- The investigation of mechanically responsive materials
- The basic understanding of the nanomaterial-cell interface
- The optimization of biological systems to be used for risk assessment
- The development of standards (material & biology)




THE BIO-NANO-INTERFACE – TOWARDS A FUNDAMENTAL UNDERSTANDING ON HOW NANO-MATERIALS INTERACT WITH CELLS

The development of nanomedicine-related products is extremely research-intensive. Currently, a lot of attention is being paid to nanomaterial synthesis and characterization with a major focus on nano-properties and increasing attention to the nano-surface. Biological questions have been specifically addressed in recent years and potential adverse effects are part of many studies.

For fundamental and applied studies alike, a central question addresses the state of the material in a complex biological environment. Before *in vivo* studies or clinical trials with new nanomedicinal products can be considered, much more fundamental knowledge about the nanomaterial-cell interface must be acquired. It is well-established that the cellular interaction of nanomaterials depends on their physicochemical properties, such as size, shape, and surface charge. However, prior to the materials' contact with cellular systems, nanomaterials interact with biological environments such as the cell culture media containing e.g. proteins, lipids, and electrolytes, which in turn can fundamentally alter the nanoparticles' physicochemical properties. This change can impact their cellular interaction *in vitro* and *in vivo*. In addition, cellular systems are very complex and each cell type can react very differently with the same nanomaterial [1]. To fundamentally address these questions, it is crucial to work with materials and exposure systems that are extremely well-controlled and characterized.

Only by adjusting each individual step in this process, by concentrating on greater precision and reproducibility, and by standardizing materials and methods alike it will be possible to improve the understanding of very complex systems, which will, in turn, facilitate closing the gap between scientific interest and commercial applications in the future.

Several research projects of the BioNanomaterials group address this subject. For example, a recently published study investigated how the surface charge of superparamagnetic iron oxide nanoparticles (SPIONs) [2] determine the specific protein adsorption patterns towards these particles, and how such interactions may relate to the particular physicochemical characteristics of the particles within a representative biological fluid. Although very similar overall protein profiles were identified, incubation time played an important role in protein adsorption and cellular uptake (Figure 2). Many studies have shown that cells generally internalize positively surface charged nanoparticles more efficiently than e.g. neutral nanoparticles [3]. In addition to charge, it was shown that the colloidal stability of the particles also has a significant impact on cell uptake data.

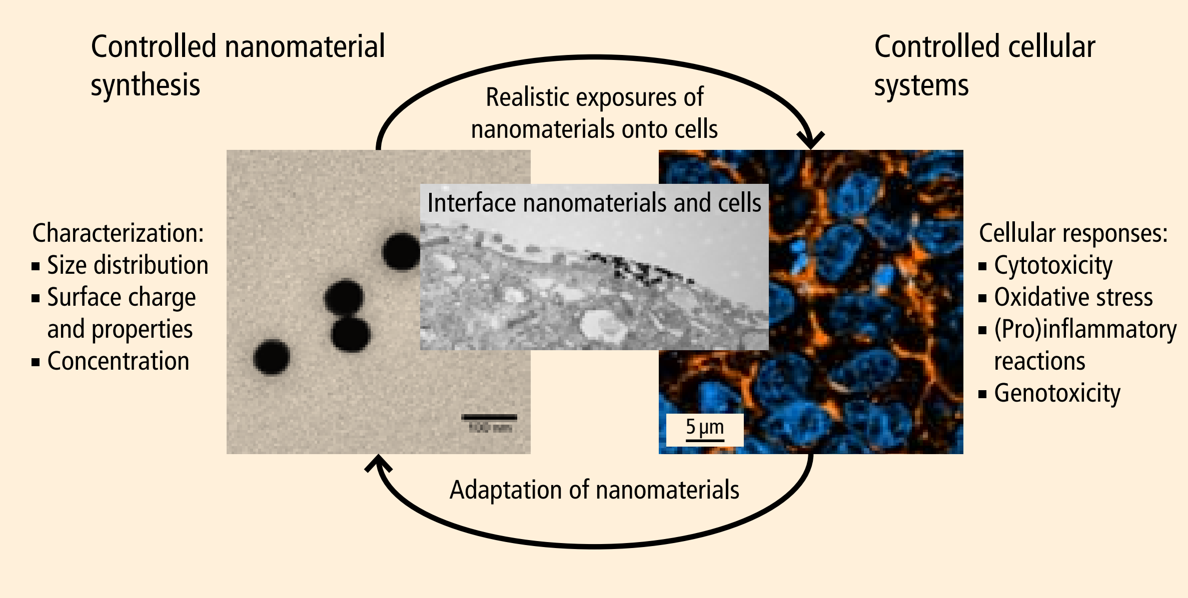


Figure 1: The fundamental understanding of the nanomaterial-cell interface is one of the major research focuses in the BioNanomaterials-group.

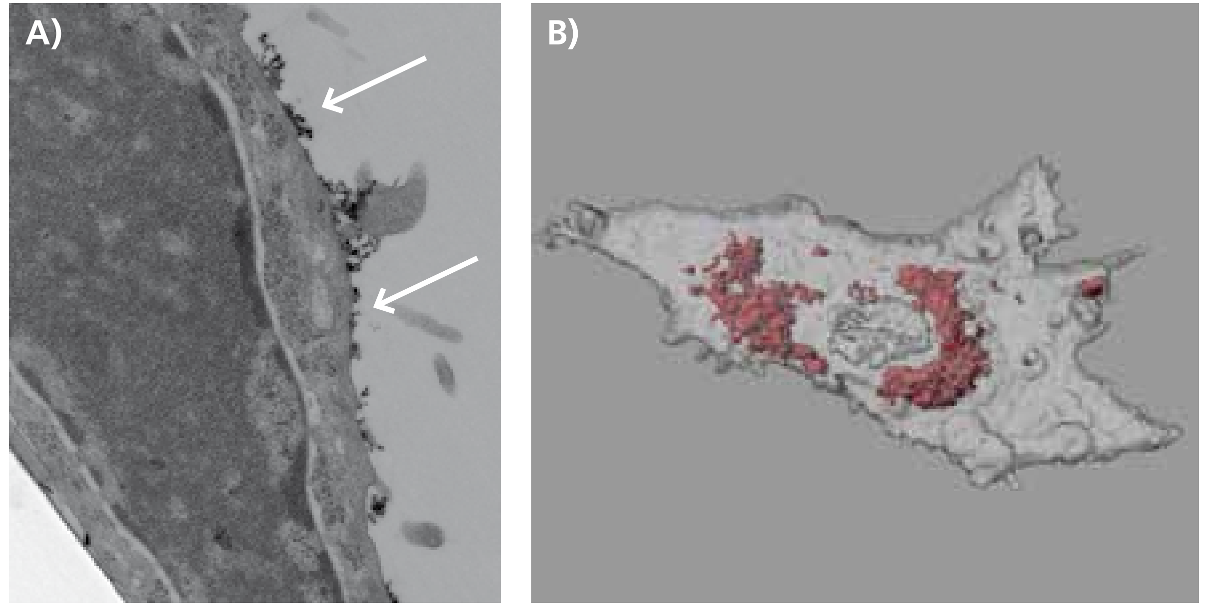


Figure 2: Interaction of fluorescently labeled and positively charged polymer coated SPIONS with HeLa cells. A) Transmission electron microscopy shows SPIONS attached to the outer cell membrane after 1 hour (arrows). B) After 24 hours, SPIONS (red) can be visualized inside cells (white, transparent rendering) by laser scanning microscopy.

The future

So far, the many studies done in this field have only touched the tip of the iceberg: physicochemical properties of materials, colloidal properties, protein corona composition and conformation, dosimetry, and nanoparticle trafficking (through biological barriers as well as between compartments and organs *in vivo*) all play very crucial roles in this complex system. In the future, our young interdisciplinary team (Figure 3) will develop a more fundamental understanding of these processes, which will facilitate the development of novel smart nanomaterials for biomedical applications.

Figure 3: The first Bionanomaterial group retreat in October 2012, Murten.

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Contact: Prof. B. Rothen-Rutishauser and Prof. A. Fink

USE OF MAGNETIC FIELDS TO CONTROL THE MICROSTRUCTURE OF POROUS SILICA GELS

Silica gels are porous materials commonly used in many applications. Their nano- and microstructure is usually characterized by a porous network of interconnected spherical particles obtained from a liquid-to-solid (sol-gel) phase transition. It has been demonstrated that magnetic nanocolloids added during the sol-gel transition can be used to control the silica microstructure through external magnetic fields, transforming silica gel into a high-tech material.

Formation of porous networks

Silica (SiO_2) is one of the most common materials on earth and is a major component in sand, glass, and many rocks. It can be produced artificially in two major forms: as colloidal silica and as a gel or aerogel. The wide variety of methods available to synthesize amorphous colloidal silica, the mild and cheap conditions required for its preparation, its chemical resistance, and the broad range of functionalization techniques developed in literature are the main reasons for the widespread use of silica in various research areas.

For most applications, especially in catalysis and as desiccants, silica gels with high porosity are used. The fabrication of such materials involves a sol-gel transition. Essentially, one starts with a liquid solution containing a suitable silica precursor, which, in the presence of a catalyst, hydrolyzes into silica nanoparticles. The progressive growth and interconnection of these particles leads to the formation of a porous network imparting solid-like properties. The most common structure of this final gel is that of a percolating network of spherical particles, shown in Figure 1.

Controlling microstructure by magnetic fields

Research at AMI has been conducted with the goal of being able to modify the sol-gel process and to transform a simple silica gel into a sophisticated nanostructured material with unique properties and structure. A simple process that allows one to control the microstructure of porous silica gels by applying external magnetic fields has been developed. The materials that can be obtained in this manner possess a wide range of microstructures, which consist of either long one-dimensional needles (Figure 2a) or of two dimensional platelets packed together (Figure 2b), depending of the magnetic field configuration used during the preparation.

The secret of the structural control consists of adding magnetic nanoparticles into the solution, which then undergoes a sol-gel transition. Magnetic nanoparticles respond to the application of a static magnetic field by self-assembling into chain-like structures. The presence of such chains drives the sol-gel phase transition into forming long needles that are loosely interconnected laterally. This phenomenon has been both qualitatively and quantitative explained by means of computer simulations, as Figure 3 exemplifies. When more complex magnetic field patterns are applied, such as rotating magnetic fields, particles assemble into two dimensional platelet structures.

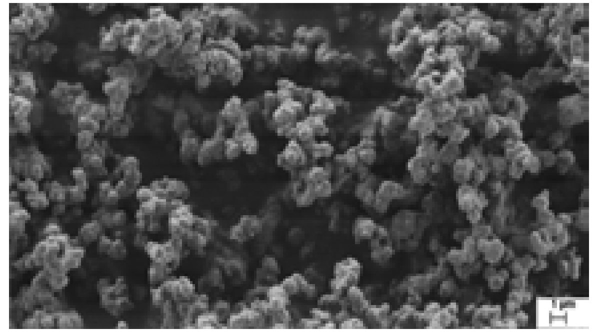

Figure 1: SEM picture of conventional silica colloidal gel.

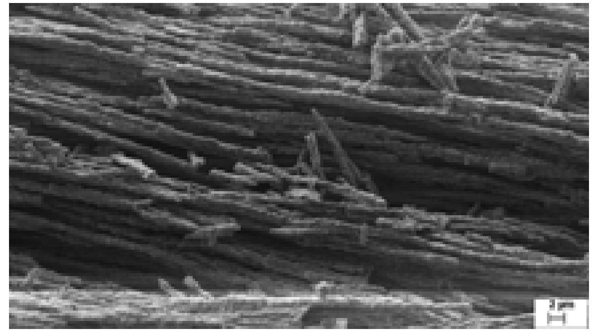

Figure 2a: SEM picture of a silica colloidal gel obtained in the presence of a static magnetic field.

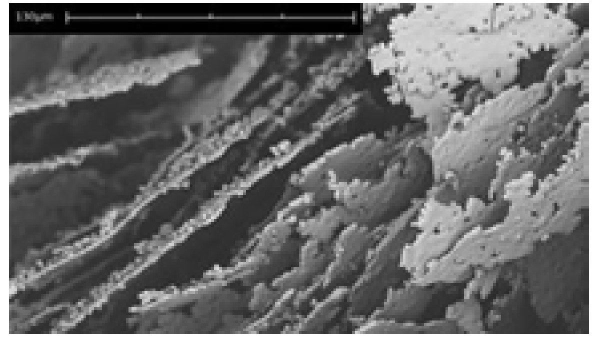

Figure 2b: SEM picture of a silica colloidal gel obtained in the presence of a rotating magnetic field.

The influence of microstructure on macroscopic properties

The microstructural differences induced by the application of a magnetic field lead to considerable differences in the macroscopic mechanical properties of the porous materials. Aligned tubular structures lead to an increased mechanical resistance in one direction, and a reduced resistance in all other directions. Aligned platelets, on the other hand, lead to an increased resistance in two directions and a reduced resistance in the perpendicular direction.

The intrinsic directional mechanical weakness of these modified silica gels has been further exploited. By applying strong ultrasonication to the macroscopic porous gel sample, selective breakage has been achieved with the goal of recovering its building blocks. In one case, magnetic micro-rods were obtained, in the other one, magnetic micro-platelets were recovered. These components are ideal candidates as smart reinforcing fillers in polymer composites, because their orientation in the polymer matrix can be magnetically controlled.

This is a great example of how nanotechnology, particularly self-assembly, can be used to modify a common material and convert it into a smart nanocomposite.

Figure 3a: Computer simulation showing the structure of a colloidal gel obtained in the absence of a magnetic field.

Figure 3b: Computer simulation showing the structure of a colloidal gel obtained in the presence of a static magnetic field.

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Contact: Prof. M. Lattuada

Organic materials are receiving more and more attention as active components in optical systems. The possibility to design their chemical structure virtually at will and exert control over their supramolecular architecture allows one to change the properties of this broad class of materials over a wide range.

In the last decade, many concepts have been explored to impart stimuli-responsive behavior (sometimes also referred to as "smartness") to organic materials. Fueled by academic curiosity and the demand for inexpensive and versatile integrated devices, stimuli-responsive materials have become the subject of intense research around the world, notably in the field of optical materials and their applications. In several projects, AMI researchers are using their experience with the assembly of small molecules and polymers to create responsive soft materials whose properties change upon exposure to light.

New data storage materials

Optical data storage systems have led to transformative advances in information storage and distribution technology. Conventional two-dimensional storage media such as CDs have allowed storage capacities necessary for high-definition video. The capacity of these media is, however, limited by the size of the disc and the number of layers that can be optically addressed. In collaboration with physicists at Case Western Reserve University in Cleveland (USA), AMI researchers have recently demonstrated how a roll-to-roll co-extrusion process can be used to fabricate a new type of optical data storage film whose total writable areas are sufficient for terabyte to petabyte-scale storage capacity, i.e., orders of magnitude higher than those possible with current commercial systems. The researchers employed a co-extrusion technique in which two polymers are melted and shaped to produce layered films consisting of 64 alternating active data storage and buffering layers with respective thicknesses of a few hundred nm and a few µm. Information can be written into the films with a laser beam, which changes the fluorescent behavior of a dye that is incorporated in the storage layers. The inactive buffer layers serve to confine the optically induced changes in fluorescence to discrete depth regions of the film. The information can be retrieved by detecting the fluorescence in a spatially resolved manner. The feasibility and high potential of this approach were demonstrated by storing and retrieving images in 23 layers of a data storage film, which is the largest number of layers in an optical data storage medium accessed to date and close to the boundaries set by the diffraction limit of the lasers employed.

Changing the color of light

Nonlinear optical materials that convert the wavelength of incident light into radiation of higher energy are useful in a plethora of applications, such as optical switching and limiting, two-photon fluorescence microscopy, photo-dynamic therapy, and optical data storage systems, as discussed above. In many cases, it is desirable or even required that the nonlinear optical material can be melt-processed into an amorphous glass, as opposed to a crystalline or semicrystalline material. However, examples of low-molecular weight nonlinear optical glasses are rare. AMI researchers have recently designed several new materials systems that can be melted, shaped, and quenched into molecular glasses and display efficient nonlinear optical responses. Glass formation was demonstrated for materials systems that display two different types of non-linear optical effects, including two-photon absorption and triplet-triplet annihilation. Both materials platforms have allowed the fabrication of thin films and more complex shapes in which the dye content and therewith the nonlinear optical responses are maximized, but where the scattering effects seen in crystalline materials are absent. AMI researchers are currently exploring the influence of confinement and connectivity on such systems.

Bonding and debonding on demand

A very different response is targeted in a new project, where AMI researchers seek to design optically-responsive adhesives, whose stickiness can be controlled upon exposure to light. The project builds on a recent breakthrough, made when AMI scientists showed that defects in supramolecular polymers can be healed upon exposure to light. Unlike conventional polymers, which consist of long, chain-like molecules with thousands of atoms, these materials are composed of smaller molecules that are assembled into longer, polymer-like chains through comparably weak interactions. Because of this, these materials behave like normal polymers in many ways, but when irradiated with intense ultraviolet light, the polymer-like chain structures are temporarily disassembled. This can be used to transform an originally solid material into a liquid that flows easily and can readily fill small defects. When the light is switched off, the structures re-assemble and the original properties are restored. AMI researchers have shown that this concept is not only useful to create healable polymers, but can also be used to create adhesive materials which permit bonding and debonding on demand. Using new materials tailored for this purpose, it was proven that objects can be readily glued together or subsequently de-bonded in seconds with the help of a lamp such as those used by dentists to cure fillings. In collaboration with an industrial partner and with support from the Swiss Commission for Technology and Innovation, AMI researchers are now exploring how this concept can be used to develop smart adhesives that meet the requirements of specific applications.

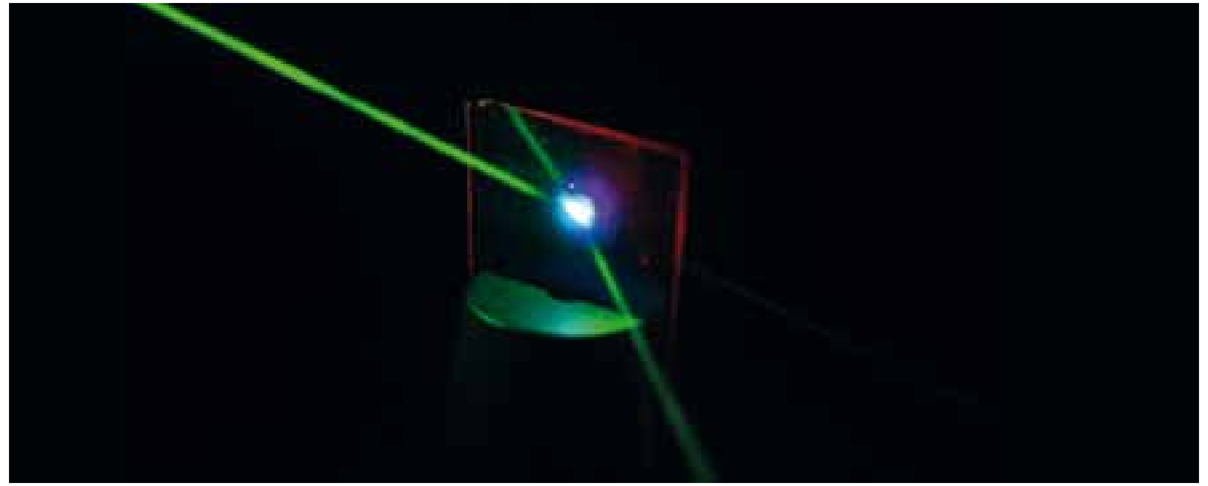


Figure 1: Picture of green to blue light upconversion in a glassy polymer.

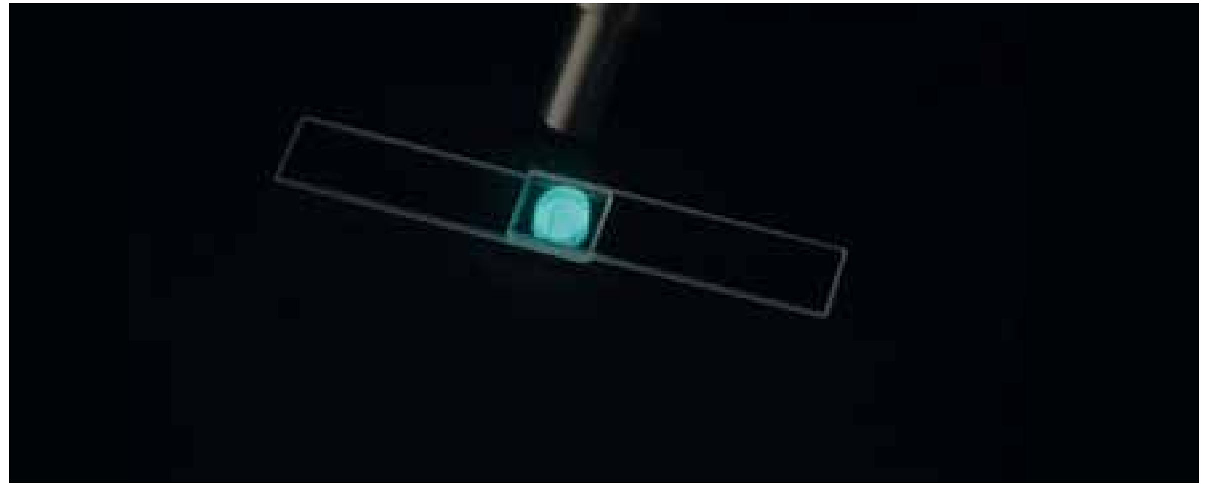


Figure 2: Picture showing the optical de-bonding of a lap joint formed with the help of a light-responsive supramolecular polymer.

References:

1. Ryan, C.; Christenson, C.W.; Valle, B.; Saini, A.; Lott, J.; Johnson, J.; Schiraldi, D.; Weder, C.; Baer, E.; Singer, K.D.; Shan, J., "High Capacity Optical Data Storage in Roll-to-Roll Multilayer Films." *Adv. Mater.* 2012 24, 5222 – 5226.
2. Simon, Y.C.; Weder, C., "Low-power photon upconversion through triplet-triplet annihilation in polymers." *J. Mater. Chem.* 2012, 22, 20793 – 21314
3. Makowski, B.T.; Valle, B.; Singer, K.D.; Weder, C., "A Melt-Processable Squaraine-Based Organic Glass for Nonlinear Optics." *J. Mater. Chem.* 2012, 22, 2848 – 2850.

Collaborations:

Research on optical data storage systems and upconverting glasses are both collaborations with the group of Professor Kenneth D. Singer at Case Western Reserve University in Cleveland, OH (USA).

Contact: Prof. C. Weder

SOFT MATTER SCATTERING

Scientists at AMI aim to understand how natural and synthetic nanostructured soft materials interact with their environment, what governs their behavior, and how they respond to diverse stimuli. The understanding of such fundamental phenomena is then applied to engineer and tailor desired functionalities that relate to structure, size, and morphology on the nanoscale. Scattering techniques represent a unique toolbox to characterize these features on the relevant length scales.

Scattering at AMI

Precise characterization of structure and dimensions on the nanoscale has become increasingly important for creating and engineering structural functionalities on the nanoscale, for example, via self-assembly. To resolve the complex spatial features of nanostructured soft materials, which are frequently organized in a hierarchical structure, requires a versatile approach. Versatility can be achieved by combining complementary methods, each dedicated to a particular characterization technique. Since its foundation, AMI has been strategically investing in the continuous development of research instrumentation and related scientific know-how, and therefore, a one-of-a-kind facility of microscopy and scattering techniques is available for the scientists and engineers. The merit of microscopic techniques, such as atomic force microscopy and electron microscopy, is the ability to directly visualize structure and morphology, while the merit of scattering techniques (X-ray, light, and neutron scattering, Figure 1) is the ability to precisely measure related dimensions. Scattering techniques are particularly relevant for soft-condensed matter because of the ease of sample preparation and the ability to study materials in their natural state.

These complementary techniques offer a full spectrum in the characterization of natural and synthetic nanostructured soft materials. Dynamic and static light scattering (DLS/SLS) precisely measure the size of nanoparticles or biomacromolecules. Depolarized dynamic light scattering (DDLS) is used to describe anisotropic features. Small-angle neutron scattering (SANS) is complementary to small-angle X-ray scattering (SAXS), due to the remarkably different interaction of photons and neutron with the atoms. While photons of X-ray and visible light interact more strongly with heavier elements, thermal neutrons are sensitive to light elements, such as hydrogen, and this technique is therefore particularly important for the study of bio-nanomaterials, where water is omnipresent. Wide-angle X-ray scattering (WAXS) focuses on interatomic lengths, and therefore characterizes the crystalline domains of synthetic and natural polymers, such as cellulose.

A selection of representative examples for nanoscale characterization of nanomaterials engineered at AMI is shown in Figure 2. There is a special interest in biologically relevant functional nanoparticles, such as gold nanoparticles. The functional properties and applications of gold nanoparticles depend on their size and shape, and, using light scattering, the dimensions can be precisely quantified (Figure 2a). Milk is extremely rich in biomacromolecules. Nanostructuring milk proteins, which are major components of cheese, holds a great potential for engineering functional materials that are completely biodegradable and originate from a truly renewable source (Figure 2b). Another project aims to improve and preserve various properties of natural wood by means of functional nanoparticles. Using SAXS, the distribution of nanoparticles in the impregnated wood can be characterized.

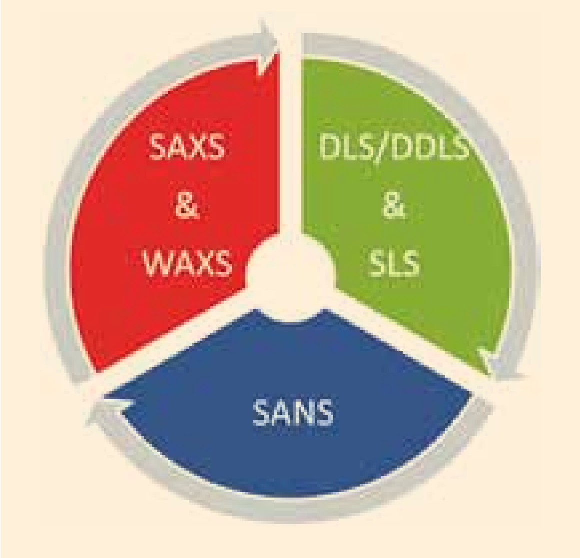


Figure 1: The three fundamental pillars of soft-matter scattering: X-rays (SAXS, WAXS), light (DLS/DDLS, SLS), and neutrons (SANS).

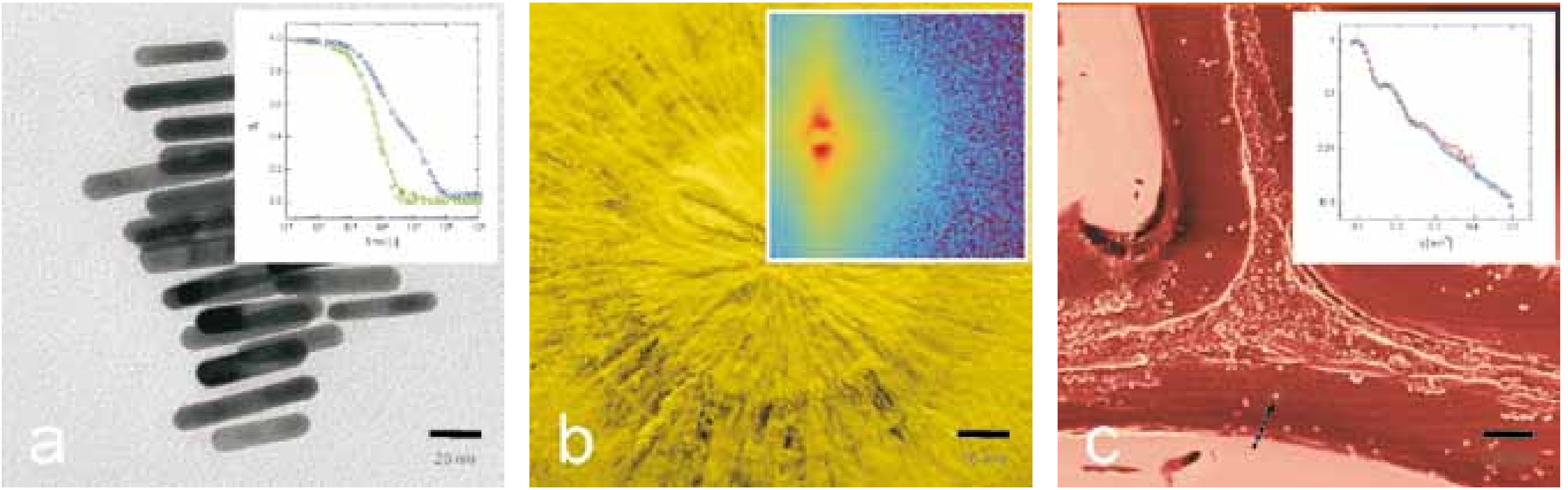


Figure 2: Synthetic and natural nanomaterials and their hybrids: examples of the application of scattering techniques. a) Image of gold nanorods as seen by transmission electron microscopy. The inset shows depolarized dynamic light scattering (DDLS) results, from which the size and polydispersity are quantified. b) Photograph of a solid foam made from natural proteins found in pure milk. The inset shows the small-angle X-ray scattering (SAXS) pattern, where from the structural organization of the milk proteins can be deducted. c) Scanning electron microscopy image of silica nanoparticles deposited onto natural pinewood. The analysis of the SAXS spectrum (inset) shows that the silica nanoparticles are homogeneously dispersed within the cellular wood structure.

Contact: Dr. Sandor Balog

PROJECTS FINANCED BY THE SWISS NATIONAL SCIENCE FOUNDATION

Bio-inspired mechanically responsive polymer nanocomposites
01.01.2010–31.12.2014
C. Weder
This experimental research program targets the design, synthesis, processing, investigation, and application of a new family of bio-inspired polymer nanocomposites with stimuli-responsive mechanical properties. The program focuses on the fundamental aspects of materials which contain cellulose nanowhiskers and change their mechanical properties on command. Such materials are of interest for potential use in biomedical and other applications.

Cellulose-based nanocomposite building materials: solutions and toxicity
01.12.2010-30.06.2014
C. Weder, J. Foster, M. Clift
This proposal outlines a research program that seeks (i) to develop new high-performance polymer nanocomposites containing rigid cellulose nanofibers and (ii) to investigate the potential health risks associated with these materials. These novel, value-added nanocomposites are designed for use in construction material applications. The investigation of the potential health risks of nanomaterials is an up-and-coming research focus at AMI.

Metal-containing polymers
01.04.2011–31.03.2014
C. Weder
This project focuses on the synthesis and characterization of metal-containing polymers, namely metallosupramolecular polymers with photo-healable properties and metal-containing materials that undergo low-power upconversion.

Processing of polymer/cellulose nanofiber composites
01.08.2012–31.07.2015
C. Weder
This proposal outlines an experimental research program that seeks to develop robust, cost-effective, and scalable methods for the mixing and processing of nanocomposites of technologically relevant polymers and cellulose nanocrystals isolated from wood.

Lanthanide supramolecular biomaterials
01.06.2012–31.05.2015
G. Fiore
The proposed research program targets the synthesis and investigation of a new class of lanthanide-containing polymers to explore their unique spectral properties and incorporation into solution assemblies for potential applications as delivery vectors and molecular probes.

Spatially resolved magneto-relaxation of *in vitro* magnetic nanoparticles using atomic magnetometry
01.09.2010–31.08.2013
A. Fink
This exploratory interdisciplinary project aims to develop a novel imaging method for specific *in vitro* biological entities, such as organs or tumor cells. These objects will be tagged by attached or embodied magnetizable nanoparticles (MNP), whose spatial magnetic field distribution, recorded by arrays of atomic magnetometers, yields images of the biological entities.

Smart vesicles for drug delivery
01.05.2010–28.02.2015
A. Fink
The goal of this project is to develop double-walled nanocontainers, so-called vesicles, whose outer wall mimicks cell membranes. Equipped with functionalized surface features for targeting selectively particular mammalian cells (e.g. cancer cells), these vesicles are designed to dock the cells or even merge with the cell membranes.

Advances in nanoparticle engineering with a focus on stability, surface, and particle-cell interaction
01.10.2009–30.09.2013
A. Fink
The project deals with model particle synthesis, colloidal property investigations, and protein profiling in environments of varying complexity. It seems that one possible and useful classification of nanoparticles is according to the manner in which they interact with proteins, an approach that has not yet been undertaken by nanoscientists. This project seeks to develop the fundamental knowledge required to address this significant limitation.

Nanotechnology: implications for the wood industry
01.01.2012–31.12.2014
A. Fink
The key objectives of this research project are to (a) understand the properties and mode of action of new engineered nanomaterials in wood science and technology, to (b) use such nanomaterials as carriers for biocides in solid wood, and to (c) evaluate the potential environmental and health related risks of nano-treated wood. With this, AMI researchers will thoroughly evaluate the potential opportunities of nanotechnology to improve the properties of one of the world's most important raw materials.

NCCR-nanoscale science
01.06.2010–31.05.2013
B. Rothen-Rutishauser
The aim of this work is to correlate the different surface properties (functionalization, surfactant coating) of multi-walled carbon nanotubes (MWCNTs) to their potential adverse effects in lung cell cultures. Different surface functionalizations of the MWCNTs, for example with positively and negatively charged groups or biosurfactant coatings, are being explored.

Biomedical nanoparticles as immune-modulators
01.09.2011–31.08.2014
B. Rothen-Rutishauser
In order to harness the unique properties of nanoparticles for novel clinical applications in the treatment of allergic respiratory diseases, AMI researchers propose developing and testing specifically designed nanoparticles in order to investigate their immune-modulatory effects in the lung.

Realistic exposure scenarios to study nanoparticle-lung cell interactions
01.01.2012–31.12.2014
B. Rothen-Rutishauser, A. Fink, M. Clift
Increased efforts have been made towards the use of sophisticated, dose-controlled nanoparticles (NP) exposure devices in combination with lung cell cultures at the air-liquid interface. However, so far, such studies have only considered acute exposures (i.e. a single exposure of NPs). AMI researchers aim to optimize their established and advanced 3D lung cell culture models to be cultured at the air-liquid interface for a prolonged period (several days to weeks). These cultures will then be used to address the questions about differences in chronic (i.e. repeated exposures as well as prolonged exposures) and acute NP exposure toxicity. In addition, co-exposure studies are planned in the second part of the project to evaluate the effects of two different NPs when combined.

Nanoparticles self-assembly: a tool for the rational design of novel materials
01.01.2012–31.12.2015
M. Lattuada
The goal of this research project is the preparation of complex nanoparticles, the understanding of their self-assembly behavior, and their utilization to prepare novel materials. The project is divided into three main projects. The first project will aim to prepare nanoparticles with structured morphologies via emulsion-based methods. The second project aims to create new polymeric and composite materials by blending different components starting from aqueous suspensions of ultra-small nanoparticles together. The last project is a computational work aimed at investigating the rheology of suspensions of colloidal particles undergoing self-assembly in the presence of flow fields.

Anisotropic self-assembly of nanoparticles
01.10.2010–30.09.2013
M. Lattuada
In this project, AMI researchers plan to investigate the behavior of particles subject to anisotropic interactions. They envision two different strategies to achieve this goal. First of all, magnetic colloids are assembled in of the presence of biaxial or triaxial magnetic fields. The second approach is based first on the preparation, and then on the systematic investigations of the properties of Janus-type asymmetrically functionalized colloids.

Fluctuations in colloidal coronas revealed by dynamic ellipsometric light scattering
01.10.2009-31.03.2012
R. Sigel
This project aimed to establish a new experimental technique to determine the softness and the rheological properties of polymers around colloidal particles. Such anchored polymers are used to stabilize colloidal materials against aggregation and precipitation. There is a high interest from industry for prediction tools for the long time stability of colloidal systems, since stability affects shelf lifetimes and concentration limits of products.

PROJECTS FINANCED BY THE EUROPEAN RESEARCH COUNCIL

Mechanically responsive polymers, ERC Advanced Grant
01.06.2012–31.05.2017
C. Weder
This program targets the design, synthesis, processing, exploration, and exploitation of a radically new family of bio-inspired, mechanically responsive polymers in which mechanical stress provides the activation energy to trigger specific pre-programmed chemical reactions.

NanoDiaRa
01.03.2010–28.02.2013
A. Fink
This project is part of a large-scale international, interdisciplinary program entitled "Nanosciences, Nanotechnologies, Materials and new Production Technologies", which involves a consortium of 15 partners. The main objective of this project is to develop modified superparamagnetic nanoparticles as a diagnostic tool for the detection of early stages of arthritis. In addition to research, the project will consider the social, ethical, and legal aspects of applying nanotechnology for medical purposes.

PROJECTS FINANCED BY OTHER PUBLIC FUNDING AGENCIES

Photo-healable supramolecular polymers, US Army Research Office
01.07.2009–30.06.2012
C. Weder, G. Fiore
The goal of this project was to develop and characterize a novel class of metallosupramolecular polymeric materials that can be healed by exposure to light of an appropriate wavelength and intensity.

Supramolecular polymers with multiple types of binding motifs: from fundamental studies to multi-functional materials, US Army Research Office
2012–2015
C. Weder
In this project, hybrid stimuli responsive materials that incorporate multiple functionality into a polymer matrix are studied.

High profit filled polymers, PST – Pôle scientifique et technologique du Canton de Fribourg
01.01.2012–31.12.2012
C. Weder, J. Foster
This project seeks to exploit synergies between the Adolphe Merkle Institute (AMI) and the College of Engineering and Architecture Fribourg (CEA) at the University of Applied Sciences of Western Switzerland, and to create a competence center capable of cutting edge melt mixing of polymers and nanofillers on the laboratory scale (1–10 g) and pilot scale (1–20 kg), with an eye on using industrially viable processes.

Biological responses to nanoscale particles, Deutsche Forschungsgemeinschaft
01.01.2011–31.12.2013,
B. Rothen-Rutishauser
This project aims to advance the understanding of the interactions of nanoparticles with proteins, tissue, and cells of the respiratory tract. A special focus lies on the interaction of proteins and other biomolecules of the body fluids with nanoparticles and the influence of these bindings on cell interaction – i.e. uptake and intracellular trafficking.

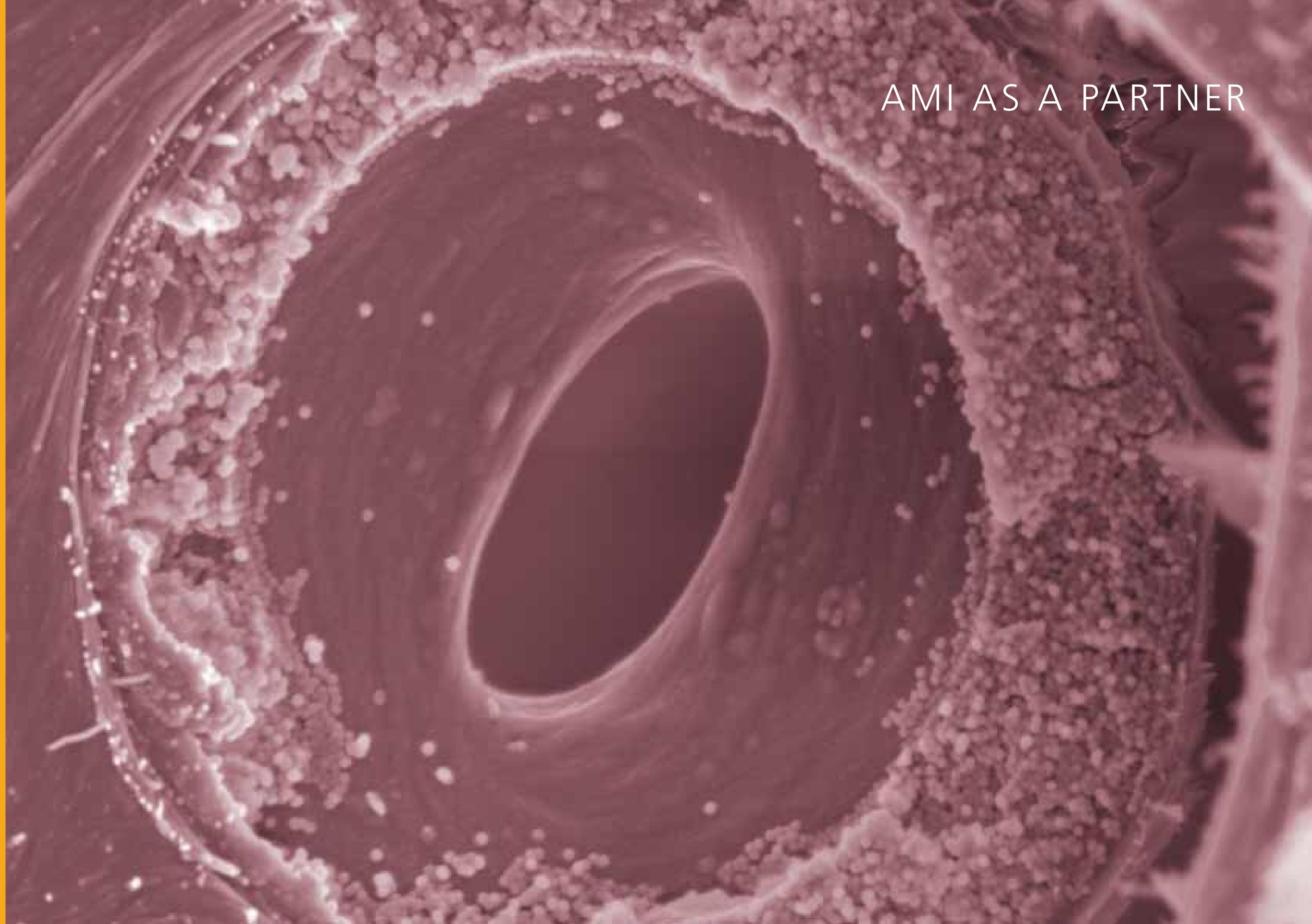
Assessing the toxicity of Ag nanoparticles at the air-liquid interface using a 3D model of the epithelial airway barrier *in vitro*, Bundesamt für Gesundheit, Swiss government
01.02.2010–31.03.2013
B. Rothen-Rutishauser
Silver nanoparticles are currently used for a wide range of consumer, industrial, and technological applications. Despite this, the effects of silver nanoparticles on the environment and human health are not fully understood. This project aims to use the *in vitro* human epithelial airway model combined with a valuable battery of experimental tests to determine the different toxicological endpoints that might be involved in xenobiotic-induced toxicity, specifically in connection with silver nanoparticles.

Modeling an *in vitro* air-blood barrier by using a novel quadruple co-culture system hosted onto an ultrathin porous membrane, Lunge Zürich
01.07.2011–30.06.2012
B. Rothen-Rutishauser
Up until now, only thick porous membranes (several μm in thickness) have been available on the market. This was not optimal for the development of an air-blood barrier with a thickness of less than 1μm. The aim of this project was to establish and characterize an *in vitro* human air-blood barrier model by using a novel co-culture system hosted onto a new ultrathin porous membrane.

PROJECTS WITH INDUSTRY

Eight projects with industry partners were carried out in 2012, five of which were fully supported by our partners, two by the Swiss Commission for Technology and Innovation, and one by the "Innovationsfonds des Kantons Freiburg".

AMI AS A PARTNER



INNOVATION AS AN INTERDISCIPLINARY CHALLENGE

Innovation requires multiple ingredients, such as technological breakthroughs, inventions, creativity, new business models, and production processes. However, none of these aspects alone lead to innovation in the context of creating and delivering new customer value in the marketplace. Thus, AMI has made it a central part of its philosophy to enable students to work hand-in-hand with people from different backgrounds and become part of this value chain.

Brainstorming, idea improvement, and idea competition

By holding after-hour meetings, AMI created a collaborative environment where participants come together to create, discuss, and improve new ideas and value propositions in a relaxing, but at the same time very stimulating atmosphere.

Students were coached to turn their ideas, which often did not have a direct connection to their research projects, into value propositions and to sketch their own business ideas. The students teamed up and challenged one another with the goal of presenting their ideas at Venture Ideas, a competition organized by Venture Lab Switzerland. Dr. Johan Foster, one of AMI's researchers won this competition and is currently working on further developing this idea.

Boot camp

Together with two other institutions in Fribourg (School of Business Administration, College of Engineering and Architecture) and the support of the economic promotion agency, AMI launched an innovation boot camp that brought 21 engineers, researchers, business students, and inventors together in September 2012. The participants had the opportunity to work with successful entrepreneurs who helped them to improve their own ideas. Two teams were selected to receive additional support and coaching to further develop their business ideas.

Innovation club

The boot camp and several other inter-institutional initiatives around the subject of entrepreneurship and innovation led to the conclusion that there is a need and an opportunity to create a club where the local student community can meet to find new inspiration, exchange experiences, and connect with interesting people from outside their usual networks. For this reason, in November 2012, the "Innovation Club Fribourg" was founded as a common platform between AMI, the School of Business Administration, the College of Engineering and Architecture, and the University of Fribourg, with the vision to make Fribourg a hot spot for young entrepreneurs.

Market analysis

In their master's program on entrepreneurship, students of the School of Business Administration Fribourg analyzed the market potential of novel *in vitro* cell models studied at AMI, which could potentially be developed into an analytical platform for drug effectiveness testing and toxicological studies. During this project, the business students were able to familiarize themselves with a specific technical field, and the project leader at AMI recieved valuable information about the market potential and possible business opportunities to commercialize this technology. In collaboration with a local start-up company, AMI is now developing a novel high-throughput platform to produce standardized *in vitro* cell models for research and testing purposes.

Industrialization

The specific methods used to create a new material with novel functionalities have an important influence on its final properties. To successfully introduce newly developed materials into real-world applications, it is of utmost importance that concepts that proved of value on the lab-scale are translated into industrially viable processes. Two joint projects were executed in collaboration with the College of Engineering and Architecture Fribourg (CEA) at the University of Applied Sciences of Western Switzerland with the goal of scaling up some of AMI's laboratory processes. The first project with Prof. T. Chappuis of the department of industrial chemistry focused on the scale-up of the hydrolysis process of cotton-based paper to individualized cellulose nanocrystals. The second project with Prof. Laure Lalande of the polymer processing lab focused on the mixing of cellulose nanocrystals as reinforcing fillers into polymeric matrices with the goal of enhancing their properties and functionality. Both projects revealed that a thorough understanding and analysis of the materials' composition and properties are detrimental to the successful adaptation of lab procedures to industrial scale processes and that material scientists and processing engineers can gain a lot by working hand-in-hand.

Prof. L. Lalende (CEA) and Dr. J. Foster (AMI) after the presentation of their results at the conference "Micro- and Nanotechnologies in Materials and Processes for the European Polymer Industry"

INDUSTRY COLLABORATIONS

Part of AMI's mission is to foster industrial competitiveness and stimulate innovation. Besides the technology transfer aspect of industry collaborations, it is also a great opportunity for our researchers to gain experiences on application challenges, different production technologies, and customer value.

In 2012, AMI collaborated with six companies from the medical devices, biomedical, pharma, adhesives, dental, and fragrances sectors. In addition to the permanent staff, four post-doctoral researchers and one PhD student worked closely with the partners' R&D departments to develop and assess new materials concepts to add value in different application fields.

One important technological platform that is being developed at AMI comprises polymeric materials that can adapt their mechanical properties as a reaction to an external stimulus. Such materials have a great potential in medical applications, where the compatibility between materials and the human body should be enhanced. In AMI's Annual Report 2011, a project that focused on using electrodes for cortical interfacing was presented. Such materials could possibly also be used in adjustable bandages with controllable stiffness to switch its properties between high comfort and a high level of fixation.

As part of a project with a German medical device producer, AMI researchers are working on the development of materials for novel introducers for venous access. A material with a very high stiffness is required in order to penetrate the skin and get to the blood vessels. However, for stationary venous access, softer materials would be preferable, as they would be much less traumatic for the sensitive vascular walls. Today, most materials used are either a compromise between the two extreme properties or comprise complicated multicomponent systems with different materials for different functions.

An adaptive material that is initially very stiff and can then soften when it comes in contact with the human body, would be ideally suited to improve the quality of life of patients with chronical or critical conditions and also simplify the work procedures for nurses. Together with a competent industry partner in this field, AMI researchers and students are working on developing such materials and have already succeeded in a first proof-of-concept for a promising class of composite materials.

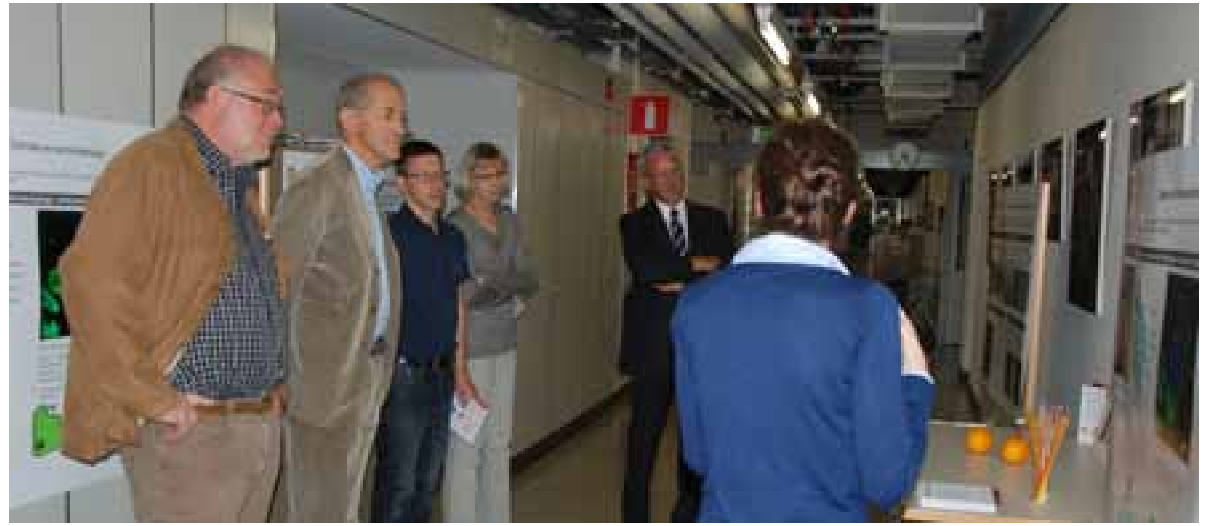
Sharing knowledge, exchanging opinions, and being involved in committed discussions are all essential sources of inspiration that help AMI to evolve and stay connected with all its key stakeholders. This is why AMI participated in or organized a number of events in 2012.

Open door day

AMI opened the doors of its labs to some local stakeholders. Selected visitors from the University of Fribourg, the University of Applied Sciences, and local colleges, as well as from the economic and political sectors came to learn more about the institute and get a feeling of what nanoscience is all about. After a short bilingual presentation of the institute, the visitors learned more about AMI's research in 4 booths, where students and professors explained and demonstrated projects on the interactions of nanoparticles with cells, smart polymers that change properties in response to an external stimulus, structure creation by self-organization of nanoparticles, and characterization tools to study nanometer sized objects.
The encounter stimulated many interesting discussions and the feedback from the participants was throughout very positive. The open door day was also a great opportunity for AMI students to explain complex content to a general audience and to enter into discussions with different stakeholders.

Mrs. Simone Merkle, widow of Founder Adolphe Merkle with Prof. Alke Fink at the open door day

Prof. Guido Vergauwen, University provost and other participants visiting the «smart polymers» booth



Vera Hirsch talking about nanoparticles properties and their use in medical applications with a group of visitors

Prof. Joseph Deiss, President of the Adolphe Merkle Foundation, in discussion with Dr. Corinne Jud and Dagmar Kuhn, visiting the characterization facilities

60th anniversary of the Swiss National Science Foundation

Prof. Alke Fink was invited to discuss the career opportunities of young researchers in Switzerland at the 60th anniversary ceremony of the Swiss National Science Foundation. For this event, around 250 participants from science, higher education institutions, and politics came together in Bern. Different workshops were held in which young researchers were able to share their experiences and articulate their views on the current situation.

Public discussion on nanotechnology

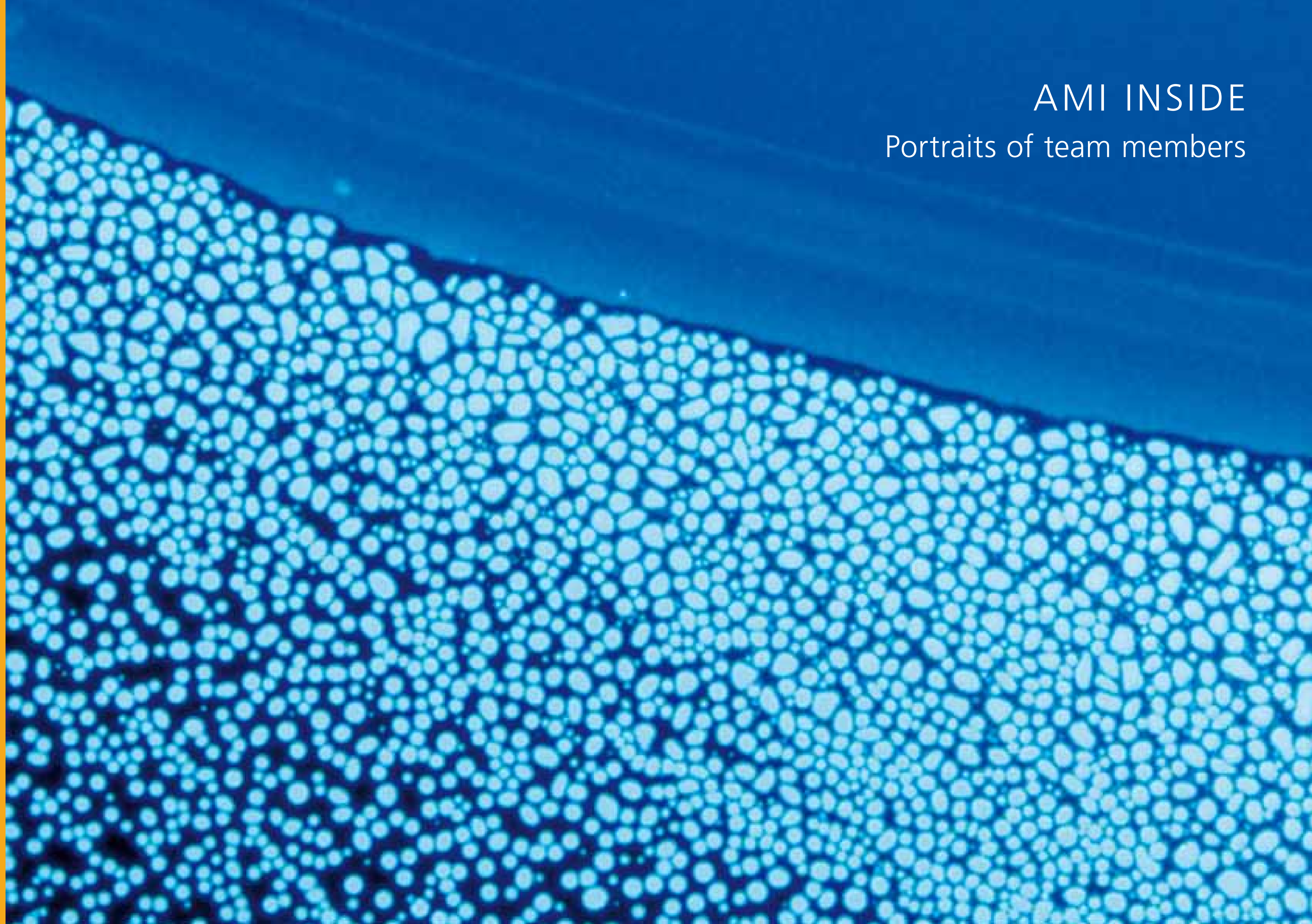
As part of a touring exhibition of the consumer protection association of western Switzerland about nanotechnology in consumer products, Dr. Marc Pauchard was part of a multidisciplinary expert panel that animated an open public discussion around the subject of «Nanotechnology: research, ethics, education».

Overview on nanoscience and – technology for high school students

In November, about 20 students from the Collège St-Michel in Fribourg visited AMI. During an overview presentation and a lab tour, the students were able to get more familiar with the fascinating world of nanoscience and -technology and were also able to gather input and material for their «Maturaarbeit», a paper that they are writing on the subject.

AMI INSIDE

Portraits of team members



REBECCA PARKHURST

After completing her PhD at the Massachusetts Institute of Technology in Cambridge (USA) near Boston, her hometown, Rebecca joined AMI's Polymer Chemistry and Materials Group in 2012 as a post-doctoral researcher. She is developing new mechanically responsive polymers in which mechanical stress induces pre-programmed chemical reactions that cause desired property changes of the material. This work is part of a larger endeavor that is supported by a European Research Council Advanced Researcher Grant. Rebecca is very excited to work on an application-oriented project and looks forward to developing smart materials that may be useful for a broad range of applications. Her stay in Switzerland is Rebecca's second extended trip to Europe as she spent part of her Bachelor's at Université Pierre et Marie Curie in Paris several years ago. She is amazed by the quality of the Swiss railway network and plans to explore the country by train. Chocolate and cheese are some of Rebecca's favorite treats so she would surely enjoy visiting the village of Gruyère close to Fribourg or the nearby chocolate factory. She also looks forward to learning to ski in the Swiss Alps.

CHRISTOPHE ALLAN MONNIER

Christophe is a real globetrotter who constantly travels around the world. Born to an American mother and a Swiss-German father, Christophe seemed to be genetically predetermined to live abroad. He spent most of his life in Basel (CH), but developed a true passion for Asia. Luckily, life brought this trilingual Swiss biologist back to Fribourg, where he was born. After getting his Bachelor and Master degrees in molecular biology at Basel's Biozentrum, Christophe joined AMI to pursue his research in bionanomaterial science with a PhD dedicated to smart drug delivery systems: using liposomes to encapsulate drugs, carry the drug inside the human body, and control the drug release directly in an infected zone. It is the multidisciplinarity at AMI and the opportunity to work in a domain that could help cure severe diseases that motivated Christophe to join AMI for his PhD. During his free time, Christophe works on promoting the understanding of biology. He is part of the team that created an inflatable model of a human white blood cell magnified 300`000 times. This giant cell travels the world now, allowing visitors to better understand biology.

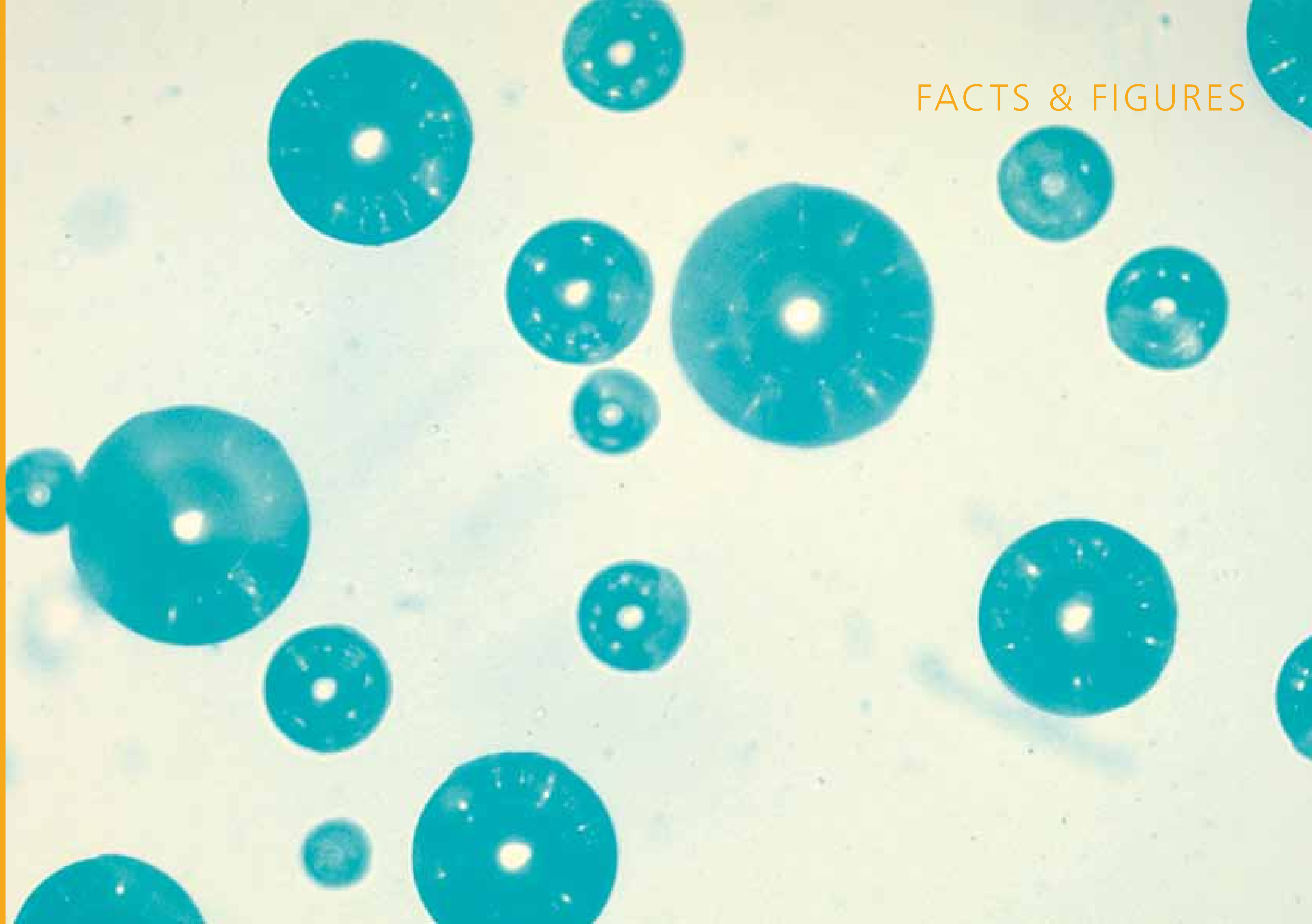
SIMONETTA RIMA

In 2012, at the age of 23, Simonetta started her PhD, making her the youngest member of the AMI team. This Italian chemical engineer says that choosing nanoparticles as a field of interest for her PhD was more a natural instinct than a rational decision. While working with monoclonal antibodies during her studies at ETH Zurich, Simonetta quickly understood how powerful nanoscience can be and what a variety of applications it has. Simonetta enjoys working at AMI because of the excellent infrastructure, the interdisciplinarity of the group members, and the perspective of developing new innovative soft materials. Used to living in the metropolitan city of Milan, Simonetta now enjoys living in Fribourg, a small and safe city that is surrounded by nature. While she is used to surfing the waves close to her hometown, Lecce, she is looking forward to improving her snowboarding skills in the mountains close to Fribourg. One of her main challenges during her stay in Switzerland will be to learn French, a goal Simonetta hopes to reach by the time she finishes her PhD.

CHRISTOPH WEDER

Christoph Weder joined AMI in 2009 to establish the Polymer Chemistry and Materials Group. In 2010, he was also named AMI's Director. Chris studied at ETH Zurich, where he received his academic degrees in chemistry and higher education, and later also earned a doctorate degree in polymer science. After a post-doctoral fellowship at the Massachusetts Institute of Technology and another appointment at ETH, where he completed a 'Habilitation', Chris spent almost nine years as a Professor for Polymer Science and Engineering at Case Western Reserve University in Cleveland (USA), before returning to Switzerland with his wife and three children. He is passionate about his work and enjoys mentoring students and senior researchers as much as he is interested in conducting research on smart polymers. Despite his group's contributions to the development of advanced fishing tackle (such as self-propelled artificial worms that wiggle when brought in contact with water), Chris's luck as a fisherman is rumored to be less than fair. Chris is well known for brewing his own beer, a hobby that combines his skills as a chemist with his love for cooking, and on occasion provides significant benefits for the AMI community.

FACTS & FIGURES

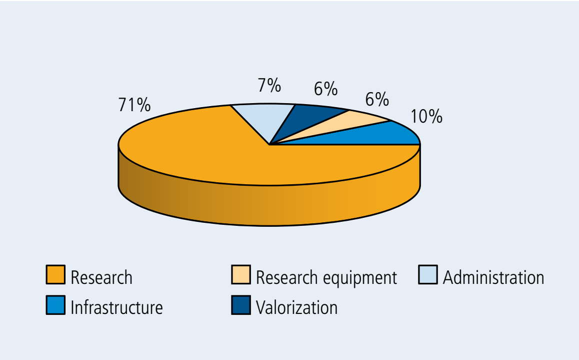


Facts & Figures

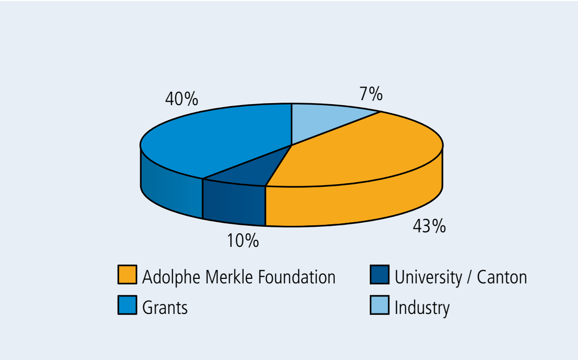
FINANCES

The institute's overall expenditures in 2012 grew to CHF 6.6 Mio. Over 70% of the expenses were spent on research and an additional 6% was invested for research equipment. About 6% of the budget supported valorization activities such as technology transfer and communication & marketing. About 10 % was used for general infrastructure and 7 % for administration. The main sources of income were the Adolphe Merkle Foundation, competitive funds from funding agencies and industry, as well as the University and Canton of Fribourg.

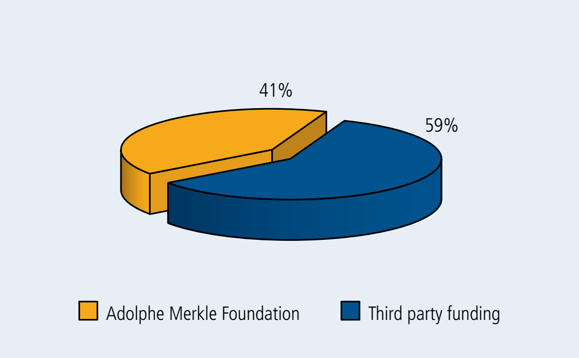
Compared to last year, the third party funding of research projects increased by CHF 1 Mio. to CHF 2.8 Mio., covering close to 60 % of all research expenditures. Here, the most important sources were the Swiss National Science Foundation (SNF), industrial partners, the Swiss Commission for Technology and Innovation (CTI), and the European Union.



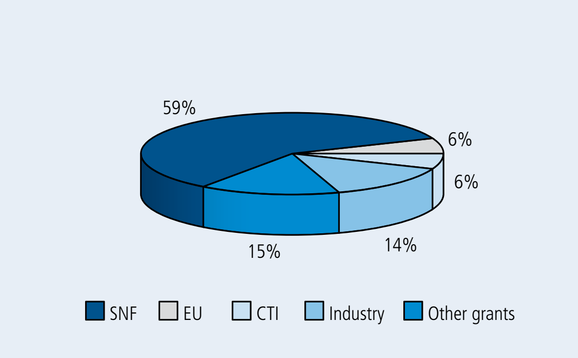
Distribution of overall expenses 2012 by cost types (total expenses of CHF 6.6 Mio.)



Sources of funding for overall expenses in 2012



Sources of funding for research projects in 2012 (total research expenditures of CHF 4.7 Mio.)

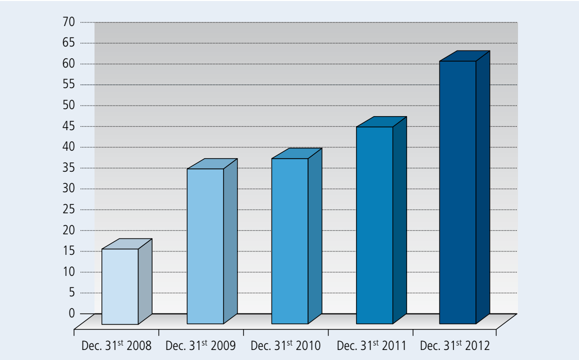


Sources of third party funding (total of CHF 2.8 Mio.)

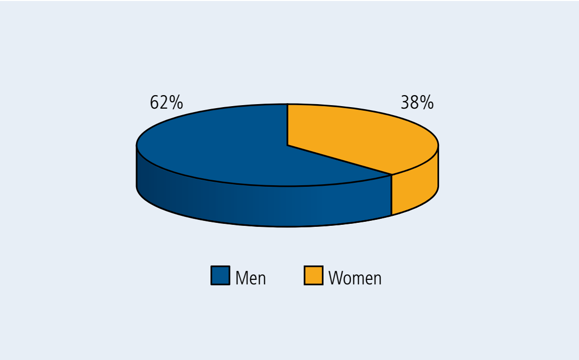
PERSONNEL

In 2012, 25 new collaborators joined AMI and 9 people left the institute due to natural fluctuation. As of December 31, 2012, 67 people worked full- or part-time at AMI, which corresponds to about 63 full-time positions. This represents a growth of 34 % for AMI in 2012. 91 % of all employees were active in research. More than half of the employees were PhD students and another 20% postdoctoral researchers, which reflects the educational mission of the institute.

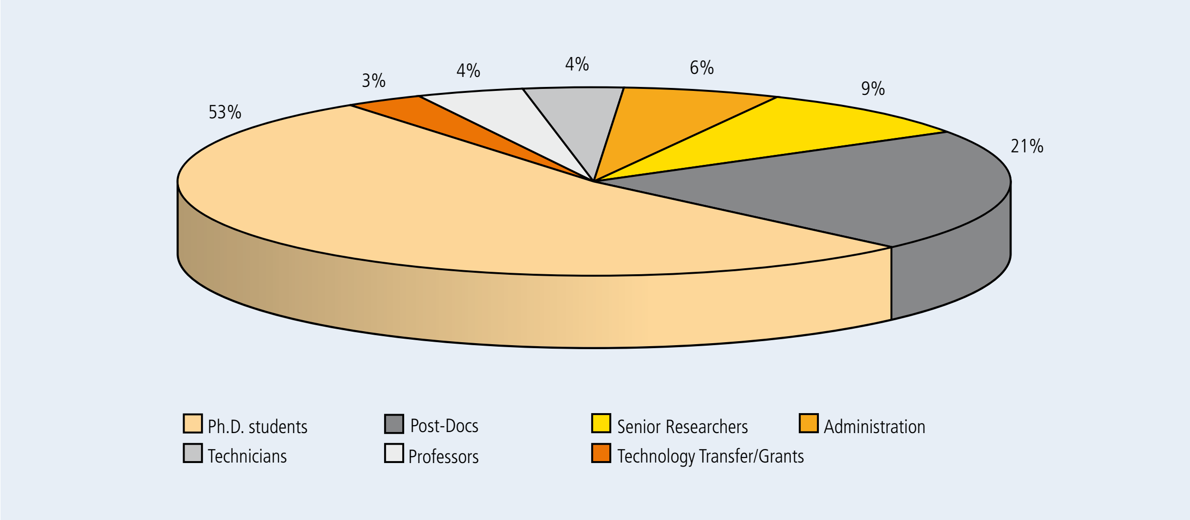
The AMI team is multinational, with 22 different nationalities represented and very young, with an average age of 32 years. The majority of AMI employees are Swiss. The next most prominent nationalities are German, French, and Italian. 38 % of employees are women.



Development of personnel over the last three years, in full time equivalents.



Gender distribution at AMI on December 31st, 2012.



Composition of personnel on December 31st, 2012.

GOVERNING BODIES OF AMI

Executive Board

Prof. Christoph Weder
(Director)

Dr. Marc Pauchard
(Associate Director)

Prof. Alke Fink

Prof. Barbara Rothen-Rutishauser

Prof. Marco Lattuada

Institute Council

Prof. Guido Vergauwen
(President)
Rector of the University of Fribourg,
Professor at the Faculty of Theology, Universtiy of Fribourg

Dr. Hans Rudolf Zeller
(Vice-President)
Former Vice-President of Technology & Intellectual Property at ABB Semiconductors

Dr. Peter Pfluger
CEO of Tronics Microsystems SA, Former CEO of the Phonak Group and of the Swiss Center for Electronics and Microtechnology (CSEM SA)

Prof. Titus Jenny
Professor of Organic Chemistry at the Department of Chemistry and Vice-Rector for Research, University of Fribourg, Former Dean of the Faculty of Science, University of Fribourg

Scientific Advisory Board

Prof. Ulrich W. Suter
(President)
Professor Emeritus at the Department of Materials, ETH-Zürich, Switzerland

Prof. Giovanni Dietler
Head Laboratory of Physics of Living Matter at École Polytechnique Fédéral de Lausanne (EPFL), Switzerland

Dr. Alan D. English
Senior Research Fellow at DuPont Central Research and Development, USA

Prof. Paula Hammond
Bayer Chair, Professor of Chemical Engineering, and Executive Officer at Massachusetts Institute of Technology, USA

Prof. Dieter Richter
Head of Institute of Solid State Research at Forschungszentrum Jülich, Germany

Prof. Ben Zhong Tang
Chair Professor of Chemistry at the Hong Kong University of Science and Technology (HKUST), China

Prof. Hans Marcus Textor
Former Head of Biointerface Group at Department of Materials, ETH Zürich, Switzerland

Adolphe Merkle Foundation

Prof. Joseph Deiss
(President)
Former member of the Swiss Government, Former President of the General Assembly of the United Nations, Professor at the University of Fribourg

Isabelle Chassot
State Councilor, Minister of Public Education, Culture, and Sport of the Canton of Fribourg, President of the Swiss Conference of Cantonal Ministers of Education

Dr. Peter Pfluger
CEO of Tronics Microsystems SA, Former CEO of the Phonak Group and of the Swiss Center for Electronics and Microtechnology (CSEM SA)

Prof. Claude Regamey
Former Chairman of the Department of Internal Medicine, Hôpital Cantonal Fribourg, Former President of the Ethical Committee of the Swiss Academy of Sciences

Dr. Hans Rudolf Zeller
Former Vice-President of Technology & Intellectual Property at ABB Semiconductors

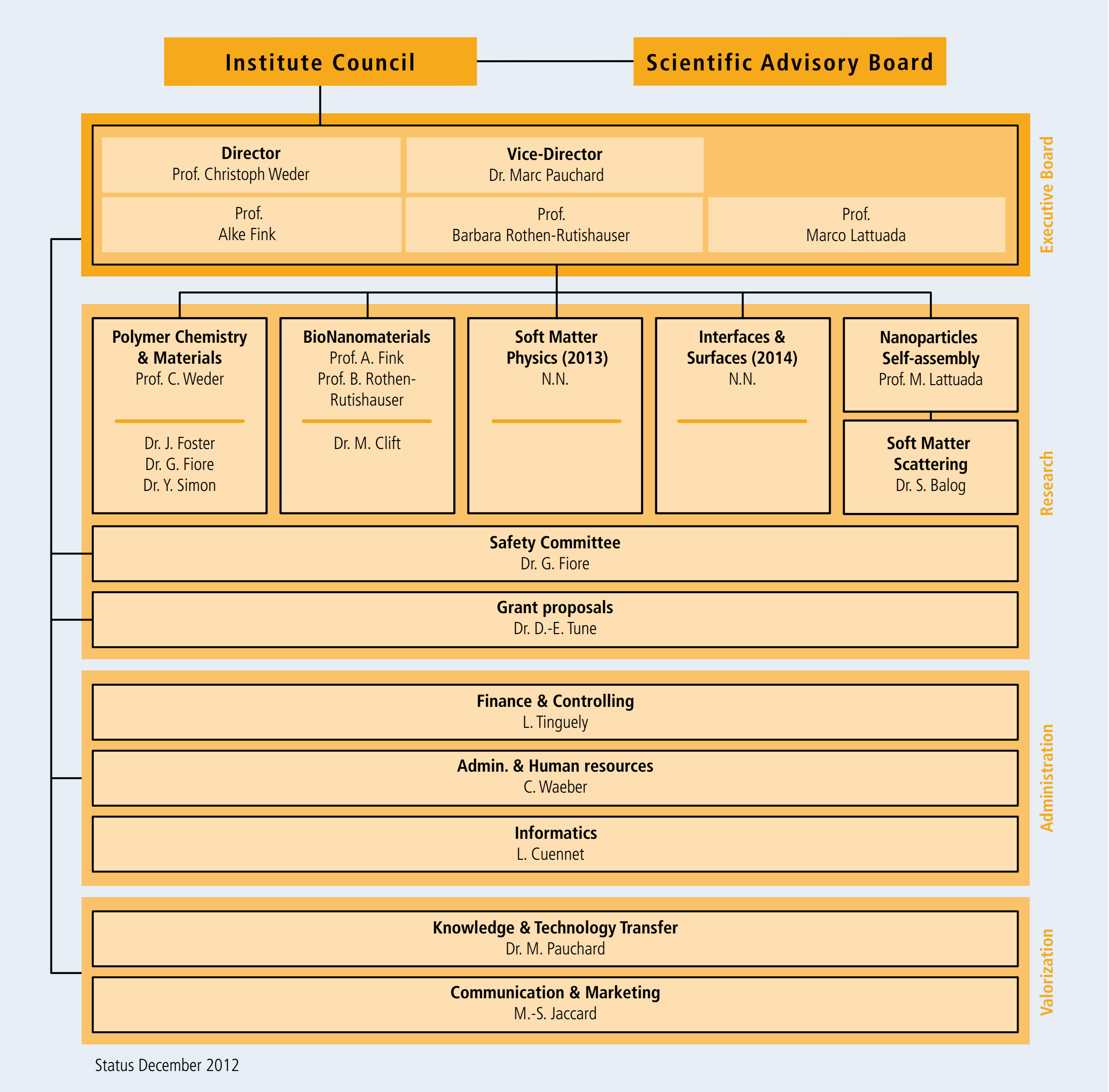
André Broye
(Managing Director)

ORGANIZATIONAL CHART

AMI has the formal status of being an independent institute of the University of Fribourg, whose scientific, administrative, and strategic leadership rest with its executive board. An Institute Council, composed of representatives of the University of Fribourg and the Adolphe Merkle Foundation, provides oversight and serves as a platform in which AMI's main stakeholders can dialogue. An independent external advisory board composed of scientists with outstanding international reputations advises the Institute Council and AMI executive board in strategic and scientific questions.

AMI's research departments form the core of the institute. In 2012, AMI comprised two research departments (Polymer Chemistry & Materials, BioNanomaterials) and two small research groups (Nanoparticles Self-assembly and Soft Matter Scattering). The current development plan foresees a continuous growth with two new departments to be installed in the coming years. Average department sizes of about 30 researchers with 2–3 group leaders are envisioned. In addition to a small administrative team, several comprehensive services endorse the strategic activities of the institute:

- Safety committee guarantees safe research operations.
- The professional support in project proposal writing guarantees AMI's efficient participation in competitive research programs.
- A technology transfer service sets the basis for successful collaborations with industry.



SCIENTIFIC OUTPUT

The scientific contribution of researchers at AMI expanded this year, with a total of 54 publications and 16 submitted manuscripts. Recent findings have been published in numerous high impact journals, such as *Soft Matter, Nanotoxicology, ACS Macro Letters, Chemical Reviews, Toxicology Letters*, and *Angewandte Chemie International Edition*. Most notably, publications from the groups of Prof. Christoph Weder, Dr. Hervé Dietsch, and Prof. Alke Fink were selected for the cover of the following journals: *Journal of Materials Chemistry, Advanced Materials, Soft Matter*, and *Magnetic Resonance in Medicine*.

The scientific network of AMI researchers was expanded by participation in over 30 international conferences. AMI researchers represented the institute and presented their latest results to the scientific community at conferences such as the American Chemical Society National Meeting, European Foundation for Clinical Nanomedicine, European Colloid and Interface Society Meeting, and the IUPAC Polymer Conference.

SCIENTIFIC OUTPUT

Publications in scientific journals:	
Published:	42
Accepted:	12
Submitted:	16
Covers:	4
Contributions at conferences and workshops:	
Invited Talks:	41
Contributed Talks:	20
Posters:	19
Keynote Lectures:	2

Publications

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68. Way, A. E.; Hsu, L.; Shanmuganathan, K.; Weder, C.; Rowan, S. J., "pH-Responsive Cellulose Nanocrystals Gels and Nanocomposites." *ACS Macro Letters* **2012,** 1001–1006.

69. Yu, Y.; Ferrari, R.; Lattuada, M.; Storti, G.; Morbidelli, M.; Moscatelli, D., "Controlled PEGylation of PLA-Based Nanoparticles." *Macromolecular Chemistry & Physics* **2012,** *213,* 2012–2018.

70. Yu, Y.; Ferrari, R.; Lattuada, M.; Storti, G.; Morbidelli, M.; Moscatelli, D., "PLA-based nanoparticles with tunable hydrophobicity and degradation kinetics." *Journal of Polymer Science Part A: Polymer Chemistry* **2012,** *50,* 5191–5200.

Conferences and Seminars

Aerztinnen und Aerzte für Umweltschutz, Luzern, Switzerland, 14 June 2012
Invited talk, "Luft ohne Schadstoffe! Klinische Folgen – Biologische Mechanismen", B. Rothen-Rutishauser

Air Pollution and Human Health – Climate Course, University of Bern, Bern, Switzerland
Invited talk, "Toxicodynamics of nanoparticles- Particle-tissue/cell interactions", B. Rothen-Rutishauser

American Chemical Society National Meeting, San Diego, CA, USA, 25–29 March 2012
Invited talk, "Bio-Inspired, Mechanically Adaptive Nanocomposites for Biomedical Implants", C. Weder
Invited talk, "Controlling the Properties of Mechanically Adaptive Polymer/Nanocellulose Composites", C. Weder
Invited talk, "Light-responsive cellulose nanofiber based materials", E. J. Foster

American Chemical Society National Meeting, Philadelphia, PA, USA, 22 August 2012
Invited talk, "Mechanically-adaptive bionanocomposites for biomedical applications", E. J. Foster
Talk, "Architectural Control for Enhanced Low-Power Upconversion in Polymeric Materials" S. –H. Lee, M. Schäfer, A. F.M. Kilbinger, Y. C. Simon, C. Weder

American Institute of Chemical Engineers Meeting, Pittsburgh, PA, USA, 29 October – 2 November 2012
Talk, "Fabrication of Anisotropic Porous Materials Via Magnetically-Controlled Phase Separation in Sol-Gel Processes", M. Lattuada, M. Furlan
Talk, "Breakup Dynamics of Colloidal Clusters in Shear Flow", M. Lattuada, Y. M. Harshe
Talk, "Aggregation Kinetics At High Concentrations: Beyond Smoluchowski's Diffusion-Limited Kernel", M. Lattuada
Talk, "Facile Synthesis of Silica Micro- and Nano-Rods", M. Furlan, M. Lattuada

BASF Research Seminar, St. Martin, Germany, 23-26 September 2012
Invited talk, "Stimuli-Responsive Polymers Based on Non-Covalent Interactions", C. Weder

3D Cell Culture Conference, Zurich, Switzerland
Poster, "A novel 3D model of the human air-blood barrier hosted on an ultrathin porous membrane", C. Jud, S. Angeloni, M. Liley, A. Petri-Fink, B. Rothen-Rutishauser

3D Cell Culture Workshop, Konstanz, Germany, 22-24 October 2012
Invited talk, "A 3D model of the human epithelial airway barrier for risk assessment of inhaled xenobiotics such as (nano)particles", B. Rothen-Rutishauser

Canadian Society for Chemistry Conference, Calgary, AB, Canada, 30 May 2012
Talk, "Stimuli Responsive Nanocomposites Based on Functionalized Cellulose Nanofibers", E. J. Foster

Chulalongkorn University, Bangkok, Thailand, 24 May 2012
Invited talk, "Polymer Nanomaterials with Unusual Optical Properties", C. Weder

CIMTEC 2012, Montecatini Terme, Italy, 14 June 2012
Invited talk, "Mechanically Adaptive Polymer Nanocomposites for Biomedical Implants and Other Applications", C. Weder
Talk, "Light-Activated Healing of Metallosupramolecular Polymers", G. Fiore

41e Colloque National du Groupe Français des Polymères, GFP 2012, Grenoble, France, 19–22 November 2012
Keynote lecture, "Bio-Inspired, Stimuli-Responsive, Mechanically Adaptive Polymer Nanocomposites", C. Weder

DFG SPP1313 Annual Meeting, Fulda, Germany
Poster, "Surface charges influences the protein adsorption kinetics, colloidal stability and subsequent cell interaction of polymer coated SPIONs *in vitro*", V. Hirsch, J. Salaklang, B. Rothen-Rutishauser, M. J. D. Clift, P. Gehr, A. Fink
Talk, "Surface charges influences the protein adsorption kinetics, colloidal stability and subsequent cell interaction of polymer coated SPIONs *in vitro*", V. Hirsch, J. Salaklang, B. Rothen-Rutishauser, M. J. D. Clift, A. Fink

DGBMT Jahrestagung der Biomedizinischen Technik, Jena, Germany
Poster, "Imaging of magnetic nanoparticles by atomic magnetometers", V. Lebedev, N. Castagna, A. Weis, B. Michen, A. Fink, G. Bison

DGM FA-Sitzung Polymerwerkstoffe und BIM (Bio-Inspired Materials), Golm, Denmark, 9 November 2012
Invited talk, "Bio-Inspired Mechanically-Adaptive Polymer/Cellulose Nanofiber Nanocomposites", E. J. Foster

Dutch Polymer Institute (DPI) Annual Meeting, Zeist, The Netherlands, 13 November 2012
Invited talk, "Stimuli-Responsive Polymers Based on Non-Covalent Interactions", C. Weder

European Colloid and Interface Society Meeting, Malmö, Sweden 2-7 September 2012
Talk, "Facile synthesis of magnetic silica micro- and nanorods"M. Lattuada, M. Furlan
Poster, "Breakup dynamics of colloidal clusters in shear flows", M. Lattuada, Y. M. Harshe
Poster, "Functional Silica Coated Superparamagnetic Iron Oxide Nanoparticles (SPIONs) – Preparative Aspects and Characterization", R. G. Digigow, H. Dietsch, B. Rothen-Rutishauser, A. Fink

European Foundation for Clinical Nanomedicine (CLINAM), Basel, Switzerland, 7 May 2012
Invited talk, "Nanoparticles and the Pulmonary Immune System", B. Rothen-Rutishauser

EPFL, Lausanne, Switzerland, 15 November 2012
Invited talk, "Structured polymeric-inorganic nanocomposites via magnetically-driven self-assembly", M. Furlan, M. Lattuada

ERS Annual Congress, Vienna, Austria
Poster, "The lung in a dish - a new tool to study the interaction of inhaled (nano) materials with lung cells", C. Jud, S. Angeloni, L. Müller, M. Liley, A. Petri-Fink, B. Rothen-Rutishauser

ETH Combustion Conference, Zurich, Switzerland
Talk, "Diesel Exhaust Particles and Human Health: An Insight into their (Geno)toxicity) *In Vitro*", M. J. D. Clift, S. Steiner, P. Gehr, B. Rothen-Rutishauser

FriMat Day, University of Fribourg, Fribourg, Switzerland
Poster, "Nebulisation of Cellulose Nanonwhiskers to mimic the Inhalatory Exposure to high aspect ratio Nanomaterials", C. Endes, S. Müller, S. Camarero Esponosa, E. J. Foster, D. Vanhecke, A. Fink-Petri, B. Rothen-Rutishauser, C. Weder, M. J. D. Clift

Poster, "Functional Silica Coated Superparamagnetic Iron Oxide Nanoparticles (SPIONs) – Preparation and Characterization", R. G. Digigow, H. Dietsch, B. Rothen-Rutishauser, A. P. Fink
Poster, "Surface charges influence the protein adsorption, colloidal stability and subsequent cell interaction of polymer coated SPIONs *in vitro*", V. Hirsch, C. Kinnear, M. Moniatte, B. Rothen-Rutishauser, M. J. D. Clift, A. Fink
Poster, "Magnetic nanoparticles for relaxation measurements using atomic magnetometry", B. Michen, V. Lebedev, N. Castagna, L. Ackermann, A. Weis, A. Fink
Poster, "Optimization of time-lapse live cell imaging for the analysis of nanoparticle uptake into cells by confocal microscopy", A. D. Kuhn, D. Vanhecke, K. Fytianos, M. J. D. Clift, A. Petri-Fink, B. Rothen-Rutishauser
Poster, "An Image routine for correlative light and electron microscopy", D. Vanhecke, C. Endes, V. Hirsch, A. Fink, B. Rothen-Rutishauser

Gymnasium Münchenstein, Basel, Switzerland, 30 August 2012
Invited talk, "Nanotechnologie – Nutzen und Risiken", B. Rothen-Rutishauser

Henkel, European Scientific Advisory Board Meeting, Düsseldorf, Germany, 15 October 2012
Invited talk, "Exploiting Noncovalent Interactions for the Design of Stimuli-Responsive Polymers", C. Weder

ICBC – F&E Kolloquium HS 2012 – Fachhochschule Wädenswil, Switzerland, 12 November 2012
Invited talk, "Interactions of inhaled biomedical (nano)materials with cells using an advanced 3D model of the human lung", A.Fink and B. Rothen-Rutishauser

Informationstag Centre Intégratif en Santé Humaine (CISH), Fribourg, Switzerland, 20 June 2012
Invited talk, "Analyse innovativer Nanomaterialien: Eine mikroskopische Herausforderung", B. Rothen-Rutishauser

18th International Conference on Biomagnetism, Paris, France
Poster, "Atomic magnetometers for MRX-mapping of SPIONs", V. Lebedev, N. Castagna, A. Weis, B. Michen, A. Fink, G. Bison

9th International Conference on the Scientific and Clinical Applications of Magnetic Carriers, Minneapolis, MN, USA
Talk, "Magnetic janus Liposomes for MRI and Drug delivery", C. Bonnaud, D. Demurtas, D. Vanhecke, H. Hofmann, H. Vogel, X. Montet, A. Fink
Poster, "Surface charges influence the protein adsorption, colloidal stability and subsequent cell interaction of polymer coated SPIONs *in vitro*", V. Hirsch, C. Kinnear, M. Moniatte, B. Rothen-Rutishauser, M. J. D. Clift, A. Fink

9th International Conference on Nanosciences & Nanotechnologies, Thessaloniki, Greece, 3-6 July 2012
Talk, "Effects of PEGylated gold nanoparticles on surface marker expression and antigen uptake in dendritic cells", K. Fytianos, E. Seydoux, F. Blank, A. Fink, C. von Garnier, B. Rothen-Rutishauser

IUPAC World Polymer Congress, Blacksburg, VA, USA, 25 June 2012
Invited talk, "Exploiting Noncovalent Interactions for the Design of Stimuli-Responsive Polymers", C. Weder

Jülich Soft Matter Days, Jülich, Germany, 14-16 November 2012
Invited talk, "Mechanically Adaptive Polymer Nanocomposites", C. Weder

Kolloquium "Life Sciences and Facility Management, Zurich University of Applied Sciences", Waedenswil, Switzerland, 12 November 2012
Invited talk, "Interactions of inhaled biomedical (nano)materials with cells using an advanced 3D model of the human lung", B. Rothen-Rutishauser, A. Fink

Materials Research Council (MRC) Graduate Symposium, ETH Zurich, Zurich, Switzerland, 7 June 2012
Poster, "Facile synthesis of magnetic silica micro-rods", M. Furlan, M. Lattuada

Micro- et Nanotechnologies dans les matériaux et processus pour l'industrie européenne des polymères, Fribourg, Switzerland, 22 November 2012
Invited talk, "Development and Fabrication of Nanocomposites from Polymers and Cellulose Nanocrystals", E. J. Foster

Nanobio Europe 2012, Varese, Italy, 18-20 June 2012
Talk, "Biosensing Optical Fibers for Real-Time Protease Activity Detection", B. Schyrr, S. Pasche, R. Ischer, D. Ferrario, J. –A. Porchet, G. Voirin, Y. C. Simon, E. J. Foster, C. Weder,

NanoFormulation 2012, Barcelona, Spain, 28 May – 1 June 2012
Invited talk, "Design of safe nanomaterials - What cells can tell us!", B. Rothen-Rutishauser

NANOSAFE, Grenoble, France
Talk, "Risk assessment of released cellulose nanocrystals - Mimicking inhalatory exposure", C. Endes, S. Müller, O. Schmid, D. Vanhecke, E. J. Foster, A. Petri-Fink, B. Rothen-Rutishauser, C. Weder, M. J. D. Clift

Nanotechnologie-Netzwerk: Nanotechnologie in Freiburg, Fribourg, Switzerland
Invited talk, "Nanopartikel: Design & Anwendungen", A. Fink

Nanotechnology in Fribourg, École des Ingénieurs et d' Architectes de Fribourg, Fribourg, Switzerland, 4 July 2012
Invited talk, "Self-Assembly: a powerful tool in the hands of nanoscientists", M. Lattuada

Nano Tera Meeting, Zurich, Switzerland
Poster, "Multifunctional magnetic, photoluminescent and photocatalytic nano-constructs for bio-medical applications", M. Crittin, M. Schaer, R. Digigow, L. Forró, A. Fink, A. Sienkiewicz

Nanax5, Malaga, Spain, 7 May 2012
Poster, "Controlling the surface exchange on gold nanorods", C. Kinnear, H. Dietsch, B. Rothen-Rutishauser, A. Fink

NRP 62 Topical Workshop, Bern, Switzerland, 11 May 2012
Talk, "Cellulose Nanowhisker Based Nanocomposites for Biomedical Applications", E. J. Foster

NRP 64 1st Progress Report Meeting, Bern, Switzerland, 29-30 March 2012
Talk, "Biomedical nanoparticles as immune-modulators",B. Rothen-Rutishauser

Polymer Reaction Engineering VIII, Cancun, Mexico, 6-10 May 2012
Invited talk, "Structured polymeric-inorganic nanocomposites via magnetically-driven self-assembly", M. Lattuada

Pulmonology Retreat (DKF, BERN), Bern, Switzerland
Invited talk, "Research Overview", B. Rothen-Rutishauser

Research in Life Science, Faculté des Sciences, Anatomy, University of Fribourg, Fribourg, Switzerland 11 June 2012
Invited talk, "Designing of nanomaterials: what cells can tell us", B. Rothen-Rutishauser

Rigaku European SAXS Users Meeting, Zurich, Switzerland
Invited talk, "SAXS at the Adolphe Merkle Instiute - Towards a better understanding of eye lens transparency and cataract formation", C. Jud, N. Mahmoudi, Y. Umehara, P. Schurtenberger, A. Stradner

SAG, Bern, Switzerland
Talk, "Mimicking the inhalatory exposure to cellulose nanocrystals", C. Endes, S. Müller, O. Schmid, D. Vanhecke, E. J. Foster, A. Petri-Fink, B. Rothen-Rutishauser, C. Weder, M. J. D Clift

SAMPE SETECT 2012, Luzern, Switzerland, 19 September 2012
Invited talk, "Nanocomposites with Cellulose Nanocrystals", C. Weder

Smart Polymers, Biannual Meeting of the GDCh Division of Macromolecular Chemistry, Mainz, Germany, 7–9 October 2012
Keynote lecture, "Mechanically Adaptive Polymer Nanocomposites for Biomedical Applications", C. Weder

SNF Jubiläumsanlass: Forschungsnachwuchs - Macht die Schweiz genug?, Bern, Switzerland
Invited talk, " Erfahrungsbericht", A. Fink

SNF Technical Apero, Bern, Switzerland
Invited talk, "Nano magnetic opener for drug delivery" C. Bonnaud, A. Fink

SPSJ International Polymer Conference 2012, Kobe, Japan, 11-14 December 2012
Invited talk, "Stimuli-Responsive Polymers based on Noncovalent Interactions", C. Weder

SSOM 3D Microscopy Symposium, Les Diablerets, Switzerland, 5-8 March 2012
Invited talk, "Nanomachines under the CryoTEM: Building a Nanoparticle-based Drug delivery system for cancer Diagnostics and Therapy", D. Vanhecke, C. Bonnaud, D. Demurtas, A. Fink, B. Rothen-Rutishauser

Swiss Chemical Society Fall Meeting, ETH Zurich, Zurich, Switzerland, 13 September 2012
Talk, "Facile synthesis of magnetic silica micro- rods", M. Furlan, M. Lattuada
Poster, "Janus Nanoparticles synthesis via Solvent Evaporation", F. Guignard, M. Lattuada
Talk, "Preparation and Characterization of Functional Silica Coated Superparamagnetic Iron Oxide Nanoparticles (SPIONs) ", R. G. Digigow, H. Dietsch, B. Rothen-Rutishauser, A. P. Fink
Poster, "Controlling the surface exchange on gold nanorods", C. Kinnear, H. Dietsch, B. Rothen-Rutishauser, A. Fink

Swiss CNT Information Exchange Workshop, Duebendorf, Switzerland, 23 January 2012
Invited talk, "Studying the relationship between carbon nanotube physico-chemical characterisitcs and their potential genotoxicity on the lung *in vitro*", M. J. D. Clift
Invited talk, "Investigating the interaction of cellulose nanowhiskers with varying physicochemical characteristics on the lung *in vitro*", C. Endes, M. J. D. Clift

Swiss NanoConvention, Lausanne, Switzerland, 23 May 2012
Invited talk, "Nanocarriers as inhalative medicine", B. Rothen-Rutishauser
Poster, "Multi-functional magnetic-photoluminescent-photocatalytic polymer-basedmicro- and nano-fibers obtained by electrospinning", M. Schaer, M. Crittin, A. Fink, L. Forró, A. Sienkiewicz

Swiss Soft Days, University of Geneva, Geneva, Switzerland, 1 June 2012
Poster, "Facile synthesis of magnetic silica micro-rods", M. Furlan, M. Lattuada

2012 TAPPI International Conference on Nanotechnology for Renewable Resources, Montreal, Quebec, Canada, 5 June 2012
Invited talk, "Cellulose composites with light-responsive behaviour", E. J. Foster

2nd Technology Apero, NFP 62, Bern, Switzerland, 11 May 2012
Talk, "Cellulose Nanowhisker Based Composites for Drug Delivery", E. J. Foster

3rd Technology Apero, NFP 62, Zurich, Switzerland, 4 December 2012
Talk, "Bio-Inspired Mechanically Responsive Polymer Nanocomposites", E. J. Foster

University of Pisa, Pisa, Italy, 15 June 2012
Invited seminar, "Exploiting Noncovalent Interactions for the Design of Functional Polymers", C. Weder

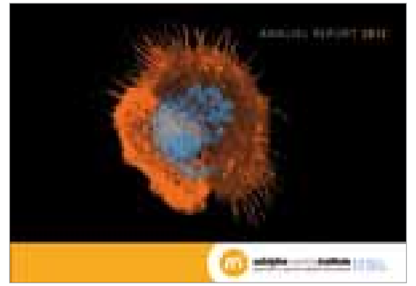
Waseda University, Department of Chemistry, Tokyo, Japan 10 December 2012
Invited seminar, "Exploiting Supramolecular Interactions for the Design of Functional Polymers", C. Weder

WINS – Women In Natural Sciences, University of Fribourg, Fribourg, Switzerland
Invited talk, "Naturwissenschaften – Frauen – na und?", A. Fink

Workshop: mobilité, couple, famille, University of Fribourg, Fribourg, Switzerland, 26 April 2012
Invited talk, "Women in Science", B. Rothen-Rutishauser

Pictures

Front cover: Dagmar Kuhn
This image shows an immune cell (macrophages in red) with gold nanoparticles inside (blue). Macrophages are important immune cells that engulf foreign (nano)particles by phagocytosis.



Page 7:
Mehdi Jorfi: Scanning Electron Microscope (SEM) image of "nano-flowers" shaped cellulose nanocrystals isolated from tunicates.

Page 15:
Christophe Monnier : two connected giant multilamellar vesicles visualized by confocal laser scanning microscopy (CLSM).

Page 31:
Christoph Geers: SEM image of beech wood impregnated with silica nanoparticles. The image shows a bordered pit of the wood cell wall with nanoparticles.

Page 37:
Roberto Vadrucci: fluorescent light microscope image of Palladium Octaethylporphyrin doped diphenylanthracene-based molecular glass droplets.

Page 41:
Roberto Vadrucci: light microscope image of Platinum Octaethylporphyrin doped diphenylanthracene-based molecular glass with bubbles.

Page 47:
Christian Heinzmann: a thin film of a supramolecular polymer melted between two glass slides

Page 57:
Christoph Geers: SEM image of beech wood impregnated with silica nanoparticles. The image shows the connection of two wood cells with nanoparticles and aggregates. This image was colored using the software gimp.

Impressum
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