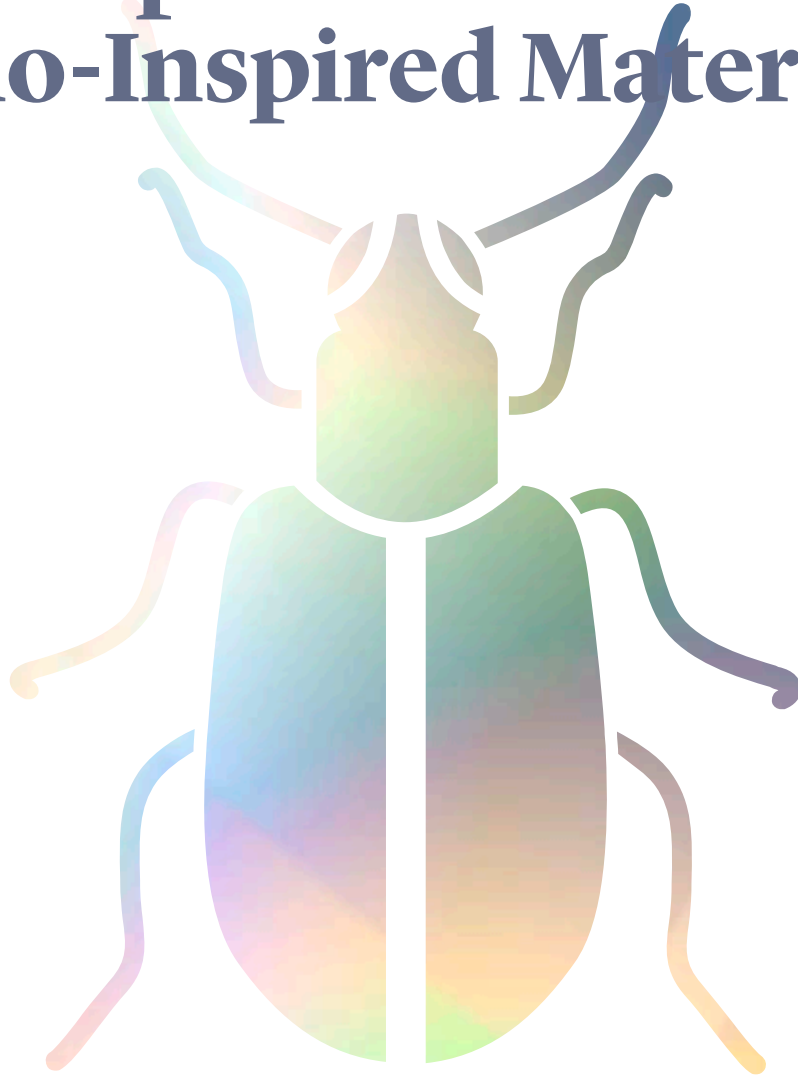


Activities report 2014 – 2016

# National Center of Competence in Research Bio-Inspired Materials





## Who we are

The National Center of Competence in Research (NCCR) Bio-Inspired Materials was launched in June 2014 with the vision of becoming an internationally recognized interdisciplinary hub for research, education, and innovation in the domain of “smart” bio-inspired materials.

We take inspiration from natural materials to establish design rules and strategies for the creation of macromolecular and nanomaterial-based building blocks and their assembly into complex, hierarchically ordered stimuli-responsive materials with new and interesting properties. We seek to develop a predictive understanding of the interactions of these materials with living cells and use the generated knowledge to develop innovative applications, particularly in the biomedical field.

Our research is organized in three modules that focus on mechanically responsive materials, responsive materials created by self-assembly, and the interactions of responsive materials with living cells. Each of these modules tackles major unsolved problems, provides opportunities for great scientific advances and requires an interdisciplinary research approach.

Our research activities are complemented with many programs that integrate research and education, support structured knowledge and technology transfer, and promote equal opportunities in science.

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Bringing scientists together to join forces in the design, synthesis and characterization of innovative materials with new and predictable functions.



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### Research

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Our researchers design artificial smart materials inspired by nature, finding ways to fight illness, create new polymers, or understand the forces surrounding us.

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### Initiatives

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Looking beyond science to have a wider impact on society.





## Editorial

# Dear readers

The National Competence Center in Research Bio-Inspired Materials has now been operating for over two years and with these lines we would like to introduce you to our first public report, which we expect to become a regular communications platform of our center.

Cooperation and collaboration are at the very core of each of the 21 current NCCRs. All of these centers, which are jointly funded by the Swiss National Science Foundation and their home institutions, are designed to enable large-scale collaborative activities and to push the boundaries of interdisciplinary research in a domain of particular national scientific, strategic and economic interests. NCCRs are expected to translate research findings into useful outcomes, contribute to the training of the next generation of scientists, and have a structuring effect on the field.

With these considerations in mind, we set out to establish an internationally recognized hub for paradigm-shifting research, innovation, and education in the domain of stimuli-responsive, or “smart”, materials whose function and design are inspired by nature. Our center is based on a simple but powerful vision: to bring scientists from very different fields together to join forces in the design, synthesis and characterization of innovative materials inspired by nature’s design and with new and predictable functions.

Over the past two and a half years, the National Center of Competence in Research Bio-Inspired Materials has progressively taken shape. We have grown from a small group of professors who six years ago began sketching the idea of a center for bio-inspired materials research into an institution that now counts fifteen research groups with over eighty researchers at four academic institutions. This was possible by quickly building an efficient

organizational structure with a professional management and support team and launching all of our planned research projects as well as several new ones. In parallel, we refined some of our strategies, and – perhaps most importantly – started to get to know each other, develop a common language, and work together. We nucleated and launched a new Master’s program on the chemistry and physics of soft materials, implemented a summer internship program for undergraduate students, crafted fellowships for women in science, and implemented a range of measures to foster equal opportunities.

This report presents an overview of our most important activities and highlights a selection of projects that have already culminated in first breakthroughs, notably in the areas of cancer detection, 3D printing of natural structures, and the development of mechanochromic materials. We hope that the report also conveys our passion and enthusiasm for our work and that you enjoy the lecture!



Christoph Weder & Curzio Rüegg  
Directors NCCR Bio-Inspired Materials



## Research

# What we do

The overarching research theme of the NCCR Bio-Inspired Materials is to use inspiration from nature for the design of artificial materials that can change their properties “on command” or, in other words, in response to an external stimulus. These materials, sometimes referred to as “smart” or “intelligent”, are of fundamental scientific interest and potentially useful in countless applications that range from climate control for buildings to drug delivery systems.

In the recent past, scientists have begun to consider nature’s principles as inspiration for the design of artificial materials with intriguing stimuli-responsive properties. Previous examples of materials studied by individual research groups that belong to the Center include mechanically adaptive nanocomposites inspired by sea cucumbers, drug-delivery nanoparticles that mimic the structure and stealth behavior of viruses, and optical elements that emulate the nanoscale patterns found in butterfly wings.

With the aim of carrying out paradigm-changing scientific breakthroughs and harnessing the huge innovation potential in this domain, the Center has launched a large-scale interdisciplinary effort that merges competences in chemistry, physics, materials science, biology, and medicine.

At the start, our research was organized in three modules that emphasized research on mechanically responsive materials, responsive materials made by self-assembly, and the interactions of responsive materials with living cells. As hoped and expected, however, the boundaries between the original projects and modules have started to blur, and several new research endeavors were launched that take full advantage of the Center’s interdisciplinary ecosystem.

## Gecko strength

# Manipulating weak forces with laser fields

Geckos and some spiders can climb walls with ease, giving the illusion they are glued to surfaces, thanks to forces called ‘van der Waals’ or ‘dispersion’ forces. The group of NCCR Principal Investigator Prof. Frank Scheffold at the University of Fribourg has demonstrated that it is possible to induce and control this type of dispersion force at the nanoscale with external laser fields.

The origin of these forces can be found in naturally present, electric and magnetic fields that fluctuate extremely fast. These fluctuations induce weak attractive, and sometimes also repulsive, forces between molecules and small bodies. The gecko uses the combined van der Waals forces of millions of small hairs to stick to a surface. As these forces on each individual hair are weak, the gecko can lift his footpad from the surface using an adapted movement.

The same forces are at play between small objects everywhere in nature and play a role for example in the behavior of biological fluids such as proteins and blood cells, as well as in some types of food or suspensions such as paint and ink. Compared to chemical bonds, these forces are relatively weak and often non-permanent. They do, however, have a strong influence on the behavior and the flow of nanoparticle suspensions and other complex fluids.

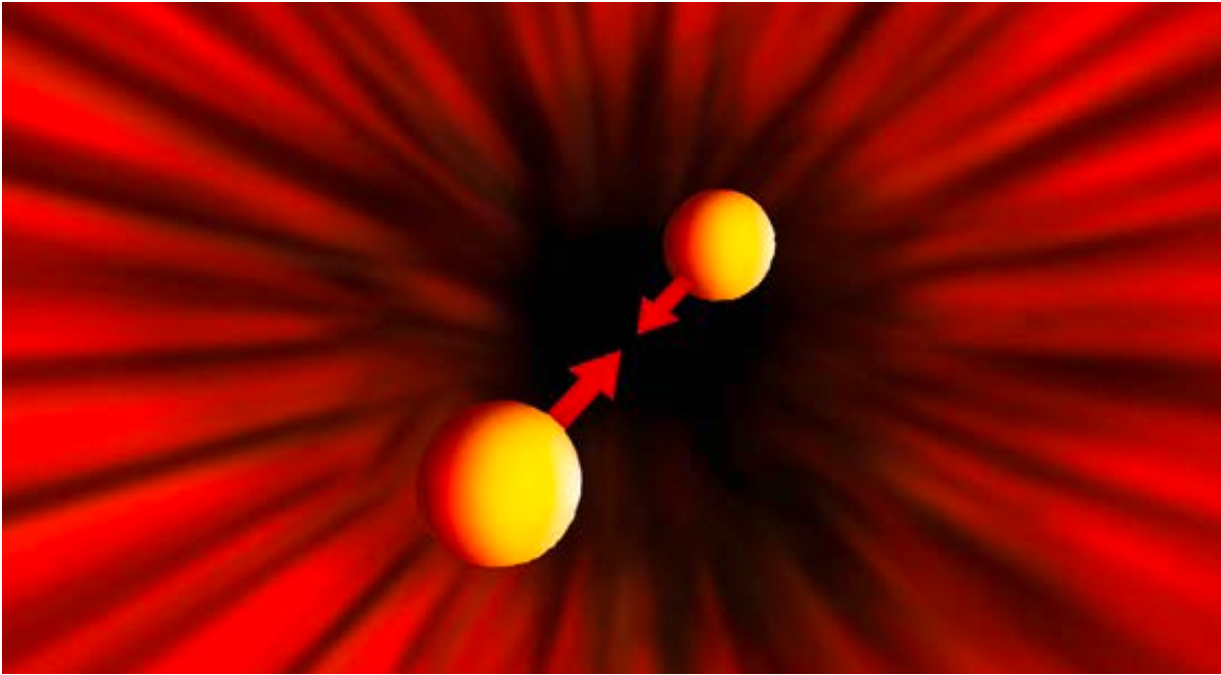
The Fribourg researchers, working with colleagues from the Universidad Autónoma de Madrid, generated a laser light cloud with properties similar to the light seen when the sun shines

through mist on a foggy day, albeit with a much higher intensity. In the experiment, two tiny micron-size plastic beads are held in place and embedded in the light cloud. The interaction force between the beads can be measured by studying precisely the relative position of the two particles with a microscope.

The higher the light intensity in the cloud, the more the two particles attract each other. Like in nature, the forces depend on the relative distance between the particles, but not their actual position within the cloud. The strength and properties of the forces present can also be controlled by the appropriate selection of the intensity and the color of the light in the cloud.

This suggests that it should be possible to completely control interactions between small bodies in two or three dimensions. This approach could facilitate the design of nanostructured materials with tailored properties and also provide new insights into their physical properties.





Two tiny plastic beads attract each other in a light cloud created by an external laser (sciex.es).

### Principle of nature

Dispersion forces between small objects are ubiquitous in nature and play a key role in the behavior observed in biological fluids such as proteins, blood cells and foodstuffs, or in suspensions such as paints and inks. Compared to common chemical bonds, these forces are relatively weak and are often not permanent. They do, however, strongly influence the behavior and the flow properties of nanoparticle suspensions and other complex fluids.

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### Reference

Brügger, G.; Froufe-Pérez, L.S.; Scheffold, F.; Saenz, J.J. Controlling dispersion forces between small particles with artificially created random light fields, *Nature Comm.*, 2015, 6, 7460.

## Three-dimensional

# Mimicking natural structures with printers

NCCR Bio-Inspired Materials researchers have developed a 3D printing system that will allow them to create models that closely mimic complex functional structures found in nature.

3D printing has almost become “old hat” over the past few years. It has gone from creating cute plastic robots to building sophisticated aircraft parts. Anyone with enough money can invest in a 3D printer and create whatever they wish out of plastic or even metal.

However, look more closely and the result can seem rough-and-ready. Higher precision techniques require substantial investment and in the industrial world, 3D printing is still often limited to prototyping before using more traditional fabrication techniques.

3D printing can also help build complex parts that would be impossible to build otherwise. NCCR Bio-Inspired Materials Principal Investigator Prof. André Studart and his team at the Swiss Federal Institute of Technology in Zurich (ETHZ) have devised a method that provides further control to the shaping process.

“The layer-by-layer approach used for printing resembles in several ways the biomineralization steps followed by living organisms to build biological materials in nature,” says Studart. “This provides us with a unique tool to fabricate syn-

thetic architectures that more closely mimic the complex functional structures found in the natural world.”

The so-called multimaterial magnetically assisted 3D printing platform (MM-3D printing) developed by Studart and his colleagues adds an extra dimension to the design possibilities by including anisotropic particles – particles in this case whose orientation can be controlled by a low magnetic field – during the printing process. Add to the mix the use of multiple precisely dosed materials and it becomes possible to produce a highly complex end product with specific properties such as an object with an internal helicoidal staircase.

“The key challenge was to identify the processing window that would allow us to print filaments that are distortion-free but also internally textured, i.e. with aligned particles,” says Studart. “We developed two separate inks: one is used for particle alignment through a magnetic field and the other is used to shape the outer contours of the desired object.”

Studart and his colleagues aim to develop functional materials with microscopic structural



MM-3D printed object with internal helicoidal staircase (A. Studart/ETHZ).

features that have only been seen so far in natural biological materials. This includes soft materials that can shift their shape based on external stimuli.

“The layer-by-layer approach used for printing resembles in several ways the biomineralization steps followed by living organisms to build biological materials in nature.” André Studart

Possible applications include biomedical implants or soft robots with autonomous shape changing capabilities; tough and lightweight composites using sustainable bio-derived polymers; and morphing wings for unmanned air vehicles.

Studart says the next steps include using the MM-3D printing platform to create bio-inspired materials with novel functionalities and properties. He also wants to create heterogeneous composites that will help understand which optimization criteria drove the natural evolution of some biological materials.

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### Reference

Kokkinis, D.; Schaffner, M.; Studart, A.R. Multimaterial magnetically assisted 3D printing of composite materials, *Nature Comm.*, 2015, 6, 8643.

## Searching

# Cancer cell detection by nature-inspired nanoparticles

NCCR researchers have taken inspiration from blood clotting to develop a new *in vitro* detection test for circulating tumor cells in breast cancer patients.

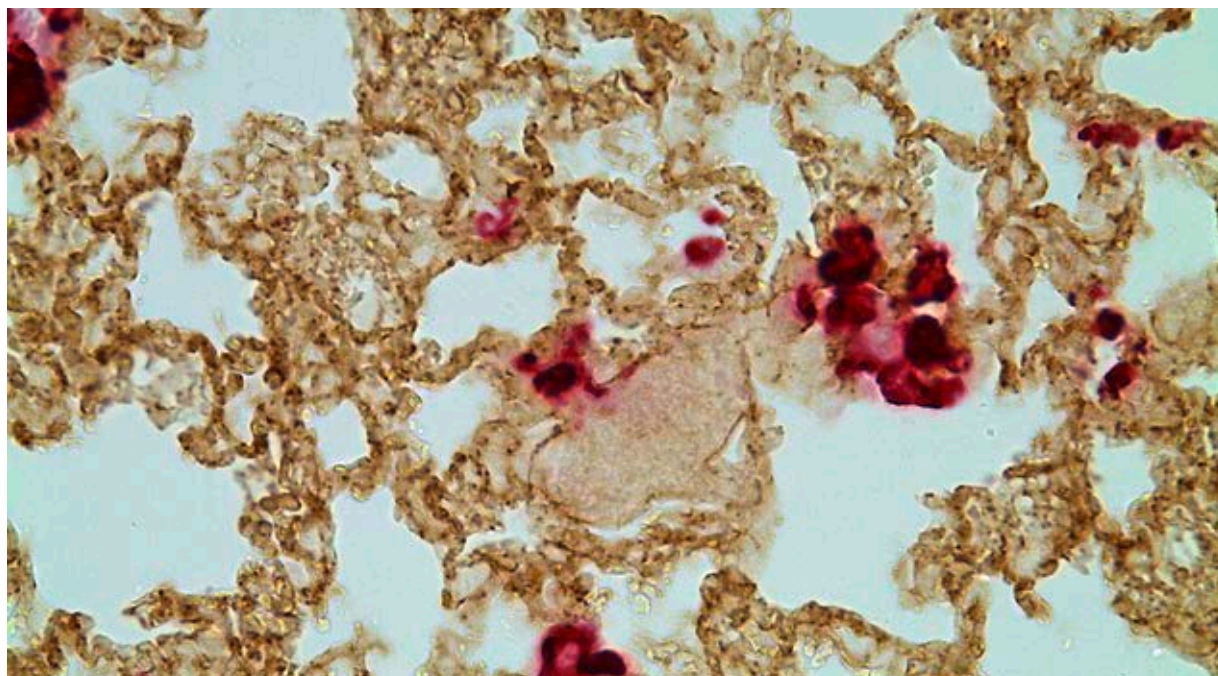
Treatment for breast cancer usually takes place in three stages. The first one involves surgery to remove the primary lesion, followed by adjuvant therapy to lower the risk of the disease making a comeback. This treatment can be hormone-based, radiotherapy, chemotherapy, or targeted therapies. It is usually carried out within a specific timeframe and in most cases patients are considered cured. However, some patients require a third level of treatment if tumors relapse, usually at distant sites. These tumors are not necessarily visible immediately. For around half of all patients, secondary tumors, also called metastases, only appear anywhere from five to seven years after their initial treatment.

In the meantime, they have been hiding in the patient's body as dormant microlesions, which to date have been undetectable and therefore untreatable. In some patients, however, circulating tumor cells (CTC) can be detected in the blood at very low frequency (around 1 CTC per 10 million normal white blood cells). Their detection poses sensitivity and specificity challenges.

To overcome this, NCCR researchers led by Principal Investigator Prof. Curzio Rüegg have chosen a novel approach using nanoparticles and inspired by the body's own clotting faculties.

Blood clotting is a highly specific and effective adaptive mechanism of the body to repair tissue lesions. Clotting results from the selective activation of initiator molecules that trigger the cascade-like activation of dormant precursor molecules in the bloodstream. This in turn sets off the conversion of fibrinogen, a soluble molecule found in the bloodstream, into insoluble fibrin. It is this stable molecule that leads to the creation of the blood clot. Thus, a small initial event (lesion) leads to a strong repair reaction through an efficient and specific amplification cascade.

The first step is to target the CTC with a specific nanoparticle carrying an antibody on its surface. This antibody will interact with a molecule expressed on the surface of a particular breast cancer subset. This nanoparticle is a gold sphere about 40 nanometers across covered with polyethylene glycol, antibody molecules and an enzyme that activates clotting. This enzyme, known either as factor III or "tissue factor," only becomes active when it comes into contact with the cancerous cell's surface. The targeting of this cell by the nanoparticle kicks off the clotting mechanism and leads to the formation of a fibrin clot on the cell surface.



Individual breast cancer cells (red), and small clusters thereof are observed in contact with the vasculature (brown) in a mouse lung at the early phase of metastatic colonization (C. Rüegg/University of Fribourg).

A second nanoparticle then takes over, latching on to the fibrin clot. It can do so because it has specific peptides and a clot-stabilizing enzyme on its surface. The fibrin clotting mechanism makes it easier for the second nanoparticle to fulfill its role and also stabilizes the artificial clot. The core of the second nanoparticle can be adapted to detect cancerous cells with high sensitivity, for example by choosing iron oxide for magnetic resonance scanning or fluorescent molecules for fluorescent detection.

NCCR researchers have so far considered how nanoparticles behave around healthy and cancerous cells produced in the laboratory. The goal of this research is to create a simple but effective *in vitro* diagnostic test that can pick up the presence of CTCs moving through the bloodstream. These cells indicate if a cancer is spreading and can be exploited as a biomarker of progression or for monitoring therapy

Current detection methods are complex, require major equipment investment and skills that can only be found in major medical centers. If the NCCR team led by University of Fribourg professor Curzio Rüegg is successful, their diagnostic test will be much simpler, and will only require adding

two types of nanoparticle to a few milliliters of blood. Clotting caused by the presence of cancerous cells could be observed with analytical equipment found in most doctors' surgeries.

As elegant and as simple as it might seem, the project is complex and demands strong knowledge of cancer biology and nanomaterials. This has led to the collaboration between the Rüegg group in the department of medicine and the Bio-Nanomaterials group at the Adolphe Merkle Institute as well as external groups.

Besides tackling cancer, the project could have other benefits, such as the experimentation of autonomous nanosystems, capable of reacting to predefined conditions in a precise and predictable fashion. In the long term, this project may further develop in two directions.

First, it may stimulate the development of new, synthetic, self-assembling materials as alternatives to fibrinogen.

Secondly, intelligent (i.e. self-regulated and self-assembling) particles may be developed to kill circulating or disseminated cancer cells as a first step toward *in vivo* therapeutic application for relapsing patients.

## Mechanical stress

# Changing colors as warning signs

NCCR researchers are developing new polymers that change their color in response to mechanical stress. This effect could be useful for a variety of applications ranging from structural health monitoring to packaging that indicates tampering.

The new polymers represent a subset of a growing class of “intelligent” materials, which change their properties “on command,” reacting to a pre-defined stimulus in a highly selective and reversible manner. There are plenty of examples of chemically, thermally, optically, or electrically responsive materials, but polymers that respond in a useful and predictable manner to mechanical stress are still few and far between.

“The concept of color-changing materials may be reminiscent of chameleons or octopuses, which can alter their appearance to camouflage or indicate their mood, but our mechanochromic materials are based on a mechanism that is very different from those at play in these animals,” says NCCR Director Prof. Christoph Weder, heads of the research program.

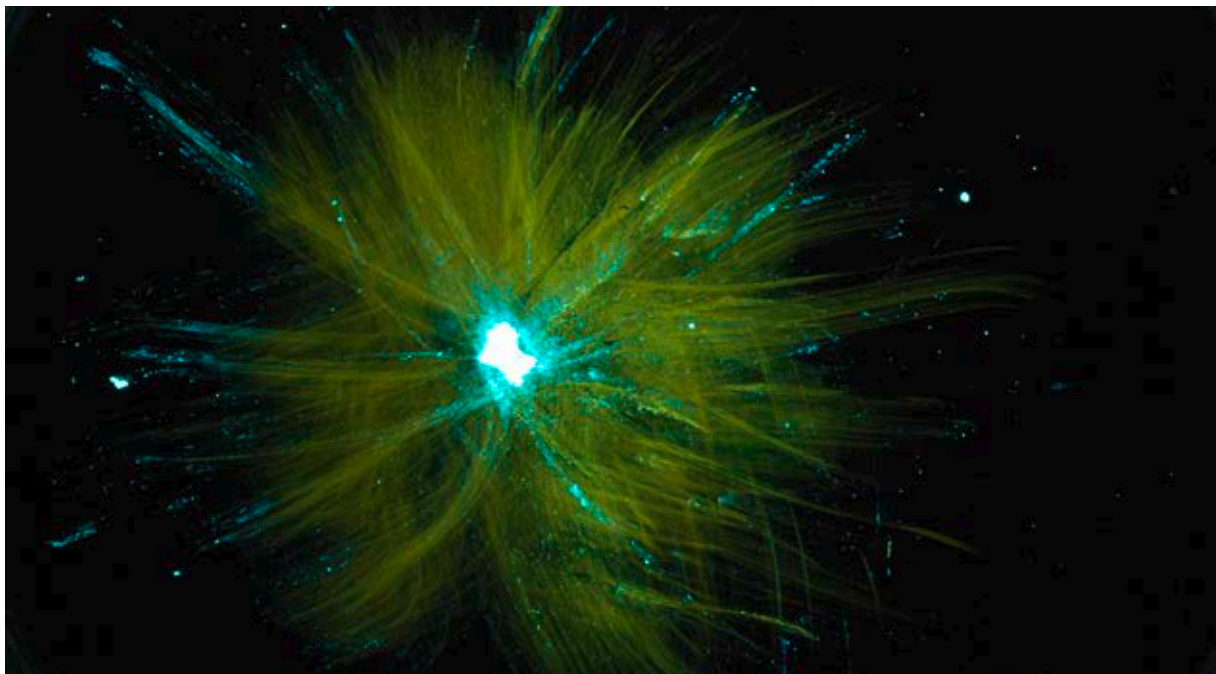
“We exploit another general design concept that is omnipresent in nature,” he adds. “Most living species have developed ways to sense and adapt to mechanical forces. The underlying signaling processes are exceedingly complex and difficult to emulate precisely, but the fundamental concept of translating mechanical forces into useful chemical reactions, also referred to

as mechanochemical transduction, has attracted widespread interest over the past decade.”

Generating this type of knowledge should ultimately make it easier to create new materials with properties such as self-lubrication, the ability to release small molecules such as drugs or fragrances, or the capacity to reinforce themselves when under load.

“At the moment, we are applying the principle of mechanochemical transduction mostly to create and study color-changing polymers. These materials are possibly useful, but the main reason to study them is that mechanically induced color changes can be easily monitored and that helps us to investigate the structure-property relations.” Christoph Weder

Polymeric materials are ideal candidates to explore mechanotransduction pathways, due to their



**Mechano-responsive luminescence behavior of a cyano-oligo(phenylenevinylene) dye, which switches from green to blue upon exposure to mechanical force (M. Karman/Adolphe Merkle Institute).**

ubiquitous nature in modern-day society and the ability to control their molecular architecture and properties. While the exposure of polymers to excessive mechanical force usually leads to nonspecific and destructive chain breakage, more useful mechanochemical responses can be achieved by incorporating specific stress-sensitive molecules known as “mechanophores.” These molecules are de facto weak links, the first to give way when the polymer containing them is placed under load. The chemical reactions associated with these mechanically triggered breaking events, in turn, can be used to bestow polymers with unusual and previously unavailable functionalities.

Molecules that change their color or fluorescence color upon mechanical activation represent one class of mechanophores in which the NCCR researchers have taken a particular interest. When embedded in a polymer, these motifs can be mechanically switched between states of different color and can thus serve to indicate strain by a change of color. While most of the color changing motifs known to be useful in this context can be switched between two colors, the NCCR team reported for the first time this year a fluorescent

compound capable of displaying five different colors when viewed under ultraviolet light.

The reversible conversion between the different colors was possible by simple mechanical or thermal treatment of the samples or by combining both approaches. Competing intermolecular interactions are ultimately responsible for the different colors. NCCR researchers are now exploring the preparation of novel stimuli-responsive materials based on the new color changing chromophores and investigating how the molecular architecture of these materials influences the mechanochromic transduction.

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### Reference

Sagara, Y.; Lavrenova, A.; Crochet, A.; Simon, Y.C.; Fromm, K.M.; Weder, C. A thermo- and mechano-responsive cyano-substituted oligo(p-phenylene vinylene) derivative with five emissive states, *Chem. Eur. J.*, 2016, 22, 4374.

## Immune effect

# High speed nanoparticle screening

Nanoparticles are considered a promising platform for therapeutics and diagnostics. However, how they interact with the immune system is still largely unpredictable and there is no universal method to screen nanoparticles for biomedical applications. NCCR researchers at the University of Fribourg and the University of Geneva are developing their own test to assess the immune effects of a variety of nanoparticles.

The research team at the University's Department of Medicine and the Adolphe Merkle Institute has been focusing on studying the interactions of nanoparticles with macrophages. These white blood cells, which are the immune system's first responders and clean-up crew, spring into action when the body detects unwanted bacteria or infected cells. They are also believed to be the first cells that take up nanoparticles.

If nanoparticle-based contrast agents or drugs are introduced into the body and the macrophages get hold of the particles, they will do their best to eliminate them from the body and negate their potentially beneficial impact. These white blood cells are also initiators of immune response and inflammation. If a nanoparticle is recognized as a danger signal, it could lead to an uncontrolled immune response. Macrophage uptake of nanoparticles is therefore usually unwanted unless the aim is precisely to target these cells to modulate the immune response.

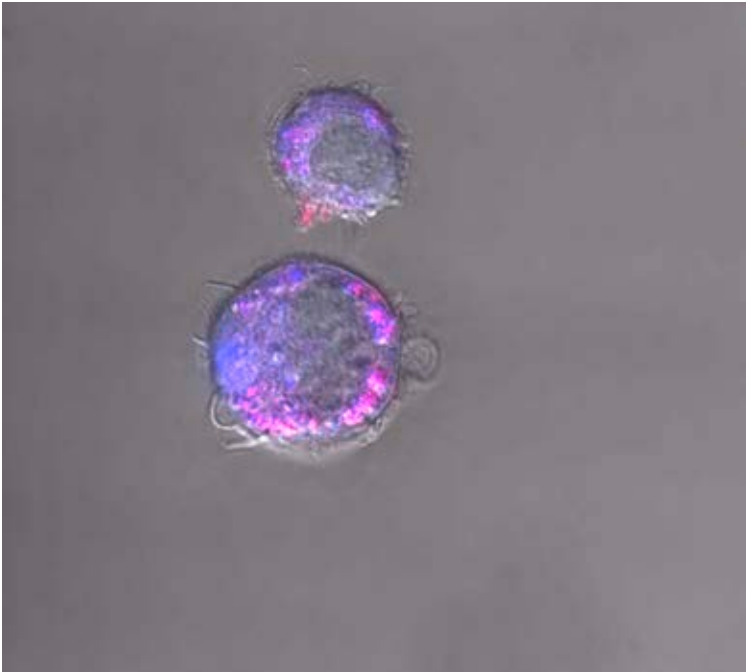
If safe and efficient nanoparticles are to be used for clinical applications, avoiding these different issues is a necessity. To test nanoparticle-macrophage interactions, the Fribourg re-

searchers have developed a screening method that allows them to see if the particles are swallowed by the cells, affect the macrophages, and trigger an immune response. This low-cost method answers all three questions within 24 hours, providing an overview of the effects of different types of nanoparticles.

To demonstrate the technique, an analysis was carried out in two steps: after being exposed to gold nanoparticles in a test well for a day, macrophages were first analyzed using so-called flow cytometry. In this method, macrophages suspended in a flow of liquid pass in front of a laser to determine if the cells were affected by the nanoparticles. Electronic detectors then register changes in the light scattered by each cell, which allows multi-parametric analysis of thousands of macrophages per second. Flow cytometry can, for example, detect changes in cell size and content, an indicator that nanoparticles were either absorbed by the macrophages or attached to their outer surface. It can also see if a cell was affected by the nanoparticles or even if it died.

In a second stage, a sample of the test liquid in which the macrophages were cultured is also





Fluorescence microscopy picture showing nanoparticle uptake into macrophages (I. Mottas/University of Fribourg).

checked for the presence of cytokines, proteins released by the macrophages to trigger an immune response.

“The bioinspiration comes from the natural interaction that macrophages have with viruses when they invade the body. The macrophages behave with nanoparticles much as they would with viruses, and this is what we measure. We are especially interested in how nanoparticles, like viruses, can initiate an immune response by flipping the first immune “switch,” the macrophage.” Carole Bourquin

The test established by the NCCR researchers is a fast, highly reproducible and cost-effective method for identifying a lead candidate between different nanoparticles. All types of particles can be run in the assay. Because the test evaluates several criteria in a single 24-hour assay, it allows

an economical use of particles. Other methods can then be used in a second step to obtain more detailed information, says lead researcher and NCCR Principal Investigator, Prof. Carole Bourquin. As these other tests are time-consuming and expensive, they can be used after the initial screen on selected lead particles.

This test is now available for all NCCR members in order to determine the immune effects of their bio-inspired nanomaterials at an early stage in their development.

## Fighting infections

# Releasing silver compounds in the body

Nanocontainers developed by NCCR Bio-Inspired Materials researchers could provide a controlled solution using silver compounds to fight infections related to biomedical implants.

As life expectancy grows, the use of biomedical implants has become more common to fix or replace those parts of the body suffering from wear and tear. Surgeons regularly replace hips or knees that no longer function properly due to overuse or age.

While this usually results in an improvement of quality of life for the patient, successful implantation is often hindered by bacterial infections. For example, when a biofilm containing bacteria becomes embedded on the surface of an implant, the solution is normally to completely remove the implant and replace it with a new one.

The result is unnecessary pain for the patient, additional medical costs, and no guarantee that this will not happen again. Heightened bacterial resistance to antibiotics means that new approaches are required to deal with these infections.

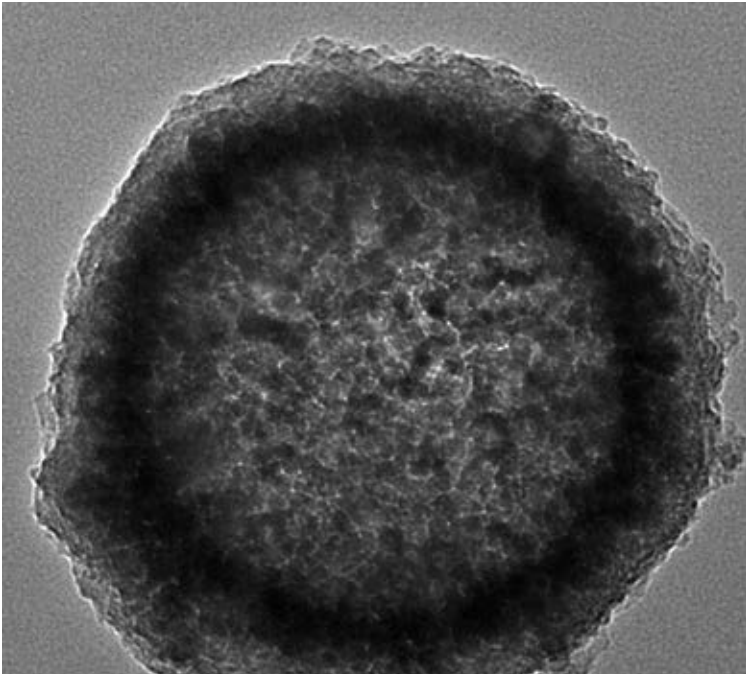
Researchers have looked to silver to deal with the problem. It has been used for thousands of years to treat wounds, breaking down the chemical bonds that bacteria require to multiply. Too much though can be toxic for tissues surrounding the area where it is applied, but it also has many advantages.

“Silver has been long tested on humans – think of silver cutlery for example,” says NCCR Principal Investigator Prof. Katharina Fromm. “Silver does also not have a role in the human body, so it will not interact with specific body functions.”

Silver-based drugs are efficient against a wide variety of bacteria. Many of them are commercially available, such as silver nitrate solutions to prevent and cure eye infections, and silver sulfadiazine in wound dressings to increase repair and prevent infections, especially in the case of burns.

However, some of the more recent silver-based drugs work extremely fast, increasing the risk of damage to surrounding tissue and of only having a short-term impact. Prolonged exposure to high silver concentrations can also lead to argyria, a non-fatal condition leading to a grayish-blue discoloration of the skin.

For implants that remain within the human body for many years, the release of silver therefore has to be controlled to avoid any undesired effects. To overcome these issues, NCCR researchers have looked at using nanocontainers to transport and slowly release silver anti-bacterial compounds.



A silver nanoparticle container with a cerium shell and titanium dioxide coating (J. Gagnon/K. Fromm, University of Fribourg).

“You use less of the drug, it is protected from degradation and delivered on demand,” adds Fromm, a professor of chemistry at the University of Fribourg. “It avoids flooding the whole body with drugs, targeting the site where it is needed the most at the appropriate time.”

The scientists developed silver-containing nanocapsules made of ceria – an oxidated form of the rare earth element cerium – with an additional coating of titanium dioxide, a compound used notably in the food industry and in sunscreen. Metal-based implants, such as hip implants, are normally made of titanium or titanium alloys whose surface oxidizes in contact with aqueous environments, making them a potential candidate for the development of antimicrobial implant surfaces.

Testing showed that the nanocontainers would release almost none of their payload in a pH-neutral environment over a three-month period, but are activated when that environment becomes acidic, similar to what happens when bacteria are present. The containers were found to be particularly effective against *E. coli*, common bacteria found in the environment as well as in foods and the intestines of people and animals.

These results suggest these nanocontainers could be used for the prevention of implant-associated infections. However it should not be considered a “silver” bullet yet.

“I believe that combinations of several antimicrobial compounds will have to be used,” says Fromm. “You will have to hit the bacteria at several places at the same time.”

More research is now required to ensure the method is less harmful towards human cells, with the long-term goal of developing a commercially viable product.

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## Reference

Gagnon, J.; Clift, M. J. D.; Vanhecke, D.; Widnerson, I. E.; Abram, S.-L.; Petri-Fink, A.; Caruso, R. A.; Rothen-Rutishauser, B.; Fromm, K. M. Synthesis, Characterization, Antibacterial Activity and Cytotoxicity of Hollow TiO<sub>2</sub>-coated CeO<sub>2</sub> Nanocontainers Encapsulating Silver Nanoparticles for Controlled Silver Release, *J. Mater. Chem., B*, 2016, 4, 1166.



This kingfisher drawn by Cécile Mathey featured on the cover of the October 2015 issue of the University of Fribourg's *Universitas* magazine, published in collaboration with the NCCR Bio-Inspired Materials.

# 85

**Researchers**

# CHF 27.1 million

**Total funding (2014–2018)**

Including CHF 12 million from the SNSF

More than

# 25 Nationalities

**Multinational**

More than 20 nationalities including Portugal, Spain, Germany, Belgium, Hungary, Croatia, USA, Ukraine, Brazil, Turkey, Iran, Nigeria and Switzerland



# Partners

**University of Fribourg  
(home institution),  
University of Geneva,  
Federal Institutes of  
Technology Lausanne  
and Zurich**

# 15

**Principal  
investigators**

# In brief

## Fellowships

**NCCR staff member Dr. Ilja Gunkel received a prestigious Marie Skłodowska-Curie Individual Fellowship, awarded by the European Commission.**

His two-year project looks at polymers that can self-assemble into well-ordered nanostructures that can be used as a template for the fabrication of new materials. Transferring the polymer nanostructure into another material often leads to a dramatic change of its optical properties: nanostructured gold, for example, not only changes color but can even be made transparent. Gunkel is a member of the Steiner Soft Matter Physics group at the Adolphe Merkle Institute.



Ilja Gunkel (right) with the NCCR Bio-Inspired Materials Knowledge Transfer and Innovation Manager Eliav Haskal.



## Media

**Bio-inspired materials were among the themes presented by the German-language Swiss public television science program Einstein.**

This TV show is one of the most important science outlet for the general public in Switzerland. NCCR Principal Investigators Christoph Weder, Alke Fink, Barbara Rothen-Rutishauser, and Ullrich Steiner all appeared in the program, which focused on nanotechnology developments. Prof. Steiner (AMI) talked notably about bio-inspiration, giving examples of how insect structures could inspire ideas for new materials.

The NCCR was also featured in the University of Fribourg's magazine Universitas, which published a special issue on the theme of bio-inspiration that included personal contributions from a number of the NCCR's principal investigators.

In addition, NCCR staff are regularly called upon regularly by the media as experts in their specific fields of research. Principal Investigator Kathari-

na Fromm (University of Fribourg) has featured on Swiss French public radio to talk about chemistry. Principal Investigator Barbara Rothen-Rutishauser featured in a documentary on the French-German cultural channel Arte "Irrespirable/Dicke Luft (Unbreathable)" broadcast in January 2016. Arte was set up by the French and German governments as a cross-border initiative and focuses on quality programming. Principal Investigator Curzio Rüegg was invited to explain how breast cancer treatments work on Swiss public television RTS' health program "36.9" (French), while Principal Investigator Francesco Stellacci (EPFL) was interviewed by the same channel about his work on oil pollution mitigation for a special program.



Yoan Simon



Martin Clift



Yoshimitsu Sagara

## Careers

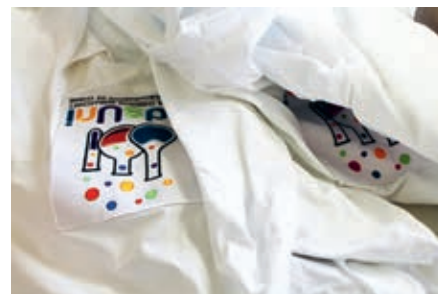
### The NCCR has seen a number of its staff move up the career ladder.

Yoan Simon of Principal Investigator Christoph Weder's Polymer Chemistry & Materials group at the Adolphe Merkle Institute was appointed Assistant Professor of Polymer Science at the University of Southern Mississippi in the United States in 2015. NCCR postdoc Dr. Yoshimitsu Sagara from the same group was offered the position of assistant professor at the Research Institute for Electronic Science, Hokkaido University (Japan). At the end of the same year, Martin Clift of Principal Investigator Barbara Rothen-Rutishauser's BioNanomaterials group at AMI moved to Swansea University in Great Britain where he has taken up a position as a Lecturer in Nanotoxicology.

## Security feature

### An NCCR-supported project on supramolecular glasses resulted in a third prize in an international ideas competition.

The idea, "Nano-security features using fluorescent supramolecular glassy materials," was one of 60 submissions at the event on January 21, 2016, in Zurich at the 3rd Thermal Probe Workshop organized by SwissLitho AG. Over 100 participants from more than 15 countries took part in the firm's first ever Young Researcher Idea Contest, working in fields as diverse as nanophotonics, plasmonics, surface analysis, and biology. Dirk Balkenende and Anna Lavrenova (NCCR), both from the Adolphe Merkle Institute, together with Samuel Zimmermann from EPFL, shared the cash prize for having created a microscale fluorescent QR code with a hidden embedded security feature.



## KidsUni

### The NCCR sponsors and supports the program "KidsUni", which organizes outreach experimental sessions for children of 10-15 years of age twice per year.

Each session typically encompasses a total of 3 afternoons, which are offered both in French and German. The program counts on the strong engagement of the NCCR staff at multiple levels. NCCR Principal Investigators Alke Fink and Katharina Fromm are the leading organizers of the program, and various Ph.D. students, postdocs, and technicians are involved in the supervision and mentoring of experiments. The last session took place in November 2015 including the participation of members of the NCCR's Weder, Lattuada, Fink, Rothen, and Zumbühl groups.



Adolphe Merkle Institute researcher Dirk Balkenende (second left) worked on the project with NCCR staff member Anna Lavrenova and EPFL's Samuel Zimmermann (center). (Photo: SwissLitho AG)

## Future scientists

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**The NCCR has contributed to the national day “Futur en tous genres – Nouvelles perspectives pour filles et garçons / Nationaler Zukunftstag” that takes place in November.**

Over the course of a day, children between the ages of 10 and 11 gain an insight into their parents’ professions. Several NCCR groups organized activities for the visiting children. The Department of Chemistry of the University of Fribourg put on a chemistry show and the Adolphe Merkle Institute offered visiting children the possibility to perform hands-on experiments, learn some basic aspects of chemistry and biology, as well delve into the mysteries of microscopes. As part of these annual activities, the children are expected to describe their experience to their classmates when they return to school.



Conference animal bio-inspiration.

## Annual conferences

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**The NCCR Bio-Inspired Materials has hosted two Annual Center Conferences since its launch in Fribourg and Murten.**

These conferences are an important element to foster collaboration and integration across the entire center. The conferences typically offer keynote lectures from prominent scientists, as well as oral presentations of individual projects and overview presentations of the NCCR programs and of available techniques within the NCCR. There are also poster sessions, parallel discussion sessions, and workshops. These workshops were tailored to Ph.D. students and postdocs and have covered topics such as scientific publishing, the ethics of materials research involving animals and intellectual property.



## Lab visits

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**The Center has organized several internal lab visits since its launch, with the aim of giving participants an overview of the research, expertise, and lab infrastructure of the host groups.**

The visits to the Department of Physics at the University of Fribourg and to the Supramolecular Nanomaterials and Interfaces Laboratory at the EPFL included introductory lectures providing an overview of the organization and research done in the respective departments followed by guided lab tours and an informal get-together. These visits also represent an opportunity to exchange ideas informally.



## Award winning

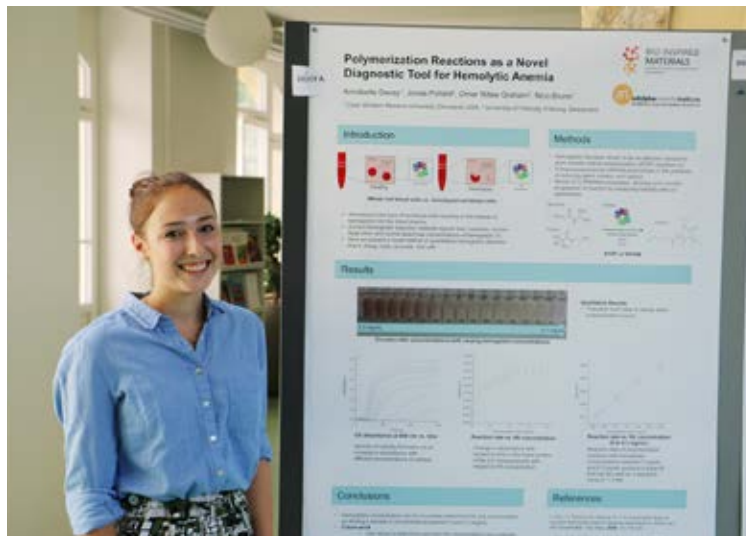
**NCCR Bio-Inspired Materials Principal Investigator Prof. Francesco Stellacci (EPFL) was the winner of the 2016 Leenaards Prize for biomedical research.**

Stellacci shared the prize, worth CHF 1.5 million, along with Professors Caroline Tapparel Vu and Laurent Kaiser of the Geneva University Hospital.

They were recognized for their project to tackle respiratory viruses using nanoparticles. The aim of their project is to develop particles that entice the viruses away from their usual target and destroy them by altering the viruses' structure. Respiratory infections kill approximately three million people around the world every year and are one of the main causes of childhood mortality according to Kaiser.



NCCR Principal Investigator Francesco Stellacci.



Annabelle Davey, winner of the 2015 student poster prize competition.

## Summer research program

**The NCCR hosted a group of undergraduate students from the United States during the summer of 2015.**

For the launch of the NCCR's Undergraduate Summer Research Internship program, the eight students hailed from Cleveland's Case Western Reserve University, the Massachusetts Institute of Technology, the University of New Hampshire, Virginia Tech, and John Carrol University.

During their eight-to-twelve-week stay, the students worked on a project alongside Ph.D. students and post-doctoral researchers at the University of Fribourg. For the students, it was an opportunity to get a glimpse of advanced research work, gain hands-on work experience, develop their transferable skills, and have a unique opportunity to explore career options and network with an interdisciplinary team of professionals.

Besides their research activities, students also attend scientific lectures and social and networking events. At

the end of the summer, the students presented the results of their research projects in a poster session followed by a summer party. Annabelle Davey of Case Western Reserve University, who worked with Ph.D. students Jonas Pollard and Omar Rifaie Graham of Principal Investigator Nico Bruns' group at the Adolphe Merkle Institute, was awarded first prize for her poster on "Polymerization Reactions as a Novel Diagnostic Tool for Hemolytic Anemia."



## Equal opportunities

# Providing role models

At Swiss universities, equal opportunities for female academics are far from a given. Gender balance is skewed in favor of male professors in the natural and life science disciplines. At the NCCR Bio-Inspired Materials home institution, the University of Fribourg, women constitute just ten percent of the science faculty professorships, the result of female researchers facing bigger hurdles to reach the top table.

Women are dropping out of academia in the sciences at a much higher rate than men. Reasons given for leaving are often long working days that are not compatible with small children, competition for funding and positions, limited contracts, difficulties finding childcare, and a lack of confidence in one's own abilities. This is a worrying situation given that in some science disciplines, as many women as men start an academic career before falling by the wayside.

Within the Center, more than half of the Ph.D. positions are filled by women. However, the number drops to four out of ten for postdoctoral researchers, while just over a quarter of the NCCR's leading positions are currently filled by women. This result is better than for most scientific organizations within Switzerland, but the Center's goal is to get much closer to gender parity at all levels.

Since its launch, the leadership team has always considered it a given that it should offer equal opportunities to all participants and be a

role model for the advancement of young scientists and the integration of women in natural and life science disciplines at all levels.

Role models have an important impact towards fulfilling that aim. The best example of how an academic career can pan out by overcoming the many hurdles faced by women is given by the leaders of the module focusing on interactions of responsive materials with cells. Professors Barbara Rothen-Rutishauser and Alke Fink are the co-chairs of the BioNanomaterials group at the Adolphe Merkle Institute.

By sharing their position, they are able to manage a large and competitive interdisciplinary team without sacrificing family life or their academic goals. It also clearly demonstrates that a career in science does not necessarily mean giving up something else, but it also means an additional effort to balance work and family life including support and understanding from their families and the working environment.

Their job-sharing arrangement, while not unique in academia, certainly attracts plenty of curiosity, with both women regularly questioned by the media and within symposia about their working relationship.

**Prof. Alke Fink (front) and Prof. Barbara Rothen-Rutishauser co-chair the BioNanomaterials group at the Adolphe Merkle Institute.**

Barbara Rothen-Rutishauser, who is also the NCCR's Faculty Delegate for the Advancement of Young Researchers and Women, says that women are not the only ones concerned by work-life balance and making the right career moves. She points out that in today's world, young male researchers often face the same issues as women when it comes to family, advancement, or career choices.

To provide career information and outside role models, the NCCR organizes bimonthly roundtable discussions led by Rothen-Rutishauser. These informal meetings are held to address the specific questions of young researchers and young parents in academia. Invited guests provide an outsider and role model's perspective, notably by presenting their alternative career paths.

In the years to come, the Center hopes these role models will inspire and encourage staff on their career path. It will continue to support the career development of Ph.D. students and postdocs as well as promote the careers of pre-tenured academic researchers. It will also actively support the employment of women up to the professorial level.

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### Equal opportunities

The NCCR Bio-Inspired Materials believes it can positively and significantly impact the careers of young researchers thanks to an unmatched variety of activities and measures ranging from career advice to the promotion of women in natural and life sciences disciplines. Its goal is to ensure that its entire staff benefit from the same favorable boundary conditions.

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### Activities

**Creation of a Postdoctoral Fellowship Program for Women in Science** to help foster the careers of talented early stage young female researchers.

**Encouraging the NCCR's female scientists, in particular its Ph.D. students, to participate in programs serving as role models for women in science, technology, engineering, and mathematics (STEM) disciplines.** These include programs such as "KidsUni," the "Schul- und Laborbesuche" promoted by GenSuisse, "Schweizer Jugend forscht / La science appelle les jeunes," or "Parents' Day."

**Organization of modules within the Women in Science and Technology (WINS) program** set up by the University of Fribourg. This annual outreach program aims to promote traditionally male technical and scientific careers to young women at a time when they are setting a course for their future professional careers.

**Providing mentoring opportunities, notably through the Undergraduate Summer Research Internship Program** that allows students to spend the summer working on research projects.

**Career coaching of female researchers, such as personal mentoring and grant writing support.**

**Supporting the participation of NCCR staff in workshops for Women in Science** such as "Strong women/strategic performance: Achieving success in meetings & negotiations" to improve leadership and negotiation skills.

**Swiss National Science Foundation 120% support grants for NCCR participants.** These grants provide Ph.D. students and postdocs with more flexibility at a critical stage of their career and needing to deal with childcare issues. It allows researchers to reduce their working hours and hire a support person for the same period to minimize delays in their research work. This funding can also be used to cover childcare costs.

**Provide active support in identifying adequate childcare possibilities and assistance in organizing emergency childcare solutions.**

**Childcare support: the NCCR Bio-Inspired Materials awards financial support to cover extra childcare expenses resulting from travel to a professional event.**



## Education

# From a high school project to a peer-reviewed scientific publication

A NCCR Bio-Inspired Materials high school student project carried out at the Adolphe Merkle Institute (AMI) laid the foundation for a publication in the journal *Macromolecular Materials and Engineering*. Adrien Holtz, who is working towards his baccalaureate at Fribourg's Gambach College, teamed up with NCCR Ph.D. student Anna Lavrenova of the AMI Polymer Chemistry & Materials group.

Adrien, who will graduate in 2017, had to carry out an individual research project as one of the requirements to earn his baccalaureate. With the support of his chemistry teacher, he was able to carry out an internship at AMI.

"These projects are the only opportunity we get to experience something new and different outside of our traditional classrooms," Adrien explained. "The most interesting part of this internship was that I was able to work in a research facility where I could learn how science is carried out."

NCCR Bio-Inspired Materials director and AMI Professor Christoph Weder invited Adrien to work on mechanochromic polymers, materials that change their absorption color in response to mechanical action. The aim was to show that a specific type of material – a polyamide – could change color under mechanical stress if blended with a specific dye.

With Anna Lavrenova as his mentor, the high school student spent two weeks on research and writing up his final report during his summer holidays. "Anna helped me through the whole process. As I had no prior knowledge of the subject

and no experience, without her patience it could have been a disaster," Adrien pointed out.

Lavrenova found the experience interesting. "The project involved quite advanced science in terms of chemistry and physics. Adrien had to come to grips with this, but he was capable afterwards of explaining what he did as well as the results to a non-specialist audience," she added.

The Ph.D. student was tasked first with explaining the project and the theory behind it to Adrien, then show him how to use various instruments, and finally work with him on his report. His project was extremely well received by his teachers and an external expert back at the college since he was awarded the maximum number of available marks.

This result was helped by the fact that Adrien's work was not only included as part of an article published in the peer-reviewed *Macromolecular Materials and Engineering* journal ("Deformation-Induced Color Changes in Melt-Processed Polyamide 12 Blends"), but the work was chosen to be featured on the journal's cover.

"When I presented my project at my school, the jury was impressed by its complexity and the fact that there was a publication from it," he said.

“Being featured on the journal cover came as a surprise to me though! I don’t think that it ever happened to anyone else at my school so I was obviously very proud of it!”

The research itself points to possible applications. Polyamides are already in widespread commercial use and the mechanochromic effect could be integrated to use them as internal strain or pressure sensors.

Adrien certainly encourages anyone tempted by his experience to do the same. “It is personal, interesting and most importantly you actually learn something new!”

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### Reference

Lavrenova, A.; Holtz, A.; Simon, Y.C.; Weder, C. Deformation induced color changes in melt processed polyamide 12 blends, *Macromol. Mater. Eng.*, 2016, 5, 549.

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### Education

When the NCCR Bio-Inspired Materials was launched, it was clear that there was little in the way of formalized training in Switzerland in interdisciplinary “soft materials” science. To overcome this education ‘gap’, the Center has chosen to integrate research and education. To achieve this, the NCCR is involved in education at all levels and ages, from elementary school all the way through to Ph.D. candidates and beyond.

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### Other education activities

**KidsUni** – The NCCR sponsors and supports the program “KidsUni,” which organizes outreach experimental sessions for children between the ages of ten and 15 twice a year. Each session typically encompasses a total of 3 afternoons, which are offered both in French and German.

**Outreach activities** – NCCR staff make regular presentations to schools or visit schools to promote science to high school students.

**Futur en tous genres/ Nationaler Zukunftstag** – Future days. The NCCR contributes to this annual national day. Children in their fifth year of primary school get to spend a day at the workplace of one of their parents to learn more about their profession and their everyday work. The Department of Chemistry of the University of Fribourg has notably put on a chemistry show and the Adolphe Merkle Institute offered visiting children the possibility to perform hands-on experiments.

**Schweizer Jugend Forscht/La science appelle les jeunes** – National science program for high school students. NCCR researchers have mentored students taking part in this program, helping them carry out experiments while learning more about careers in chemistry and materials science.

**Undergraduate Summer Research Internship (URI) Program** – The URI program allows undergraduate students, from Switzerland and abroad, to spend eight to 12 weeks working in a laboratory of an NCCR participant. Students have the opportunity to work on a research project and to interact with leading experts in their fields of interest and with fellow students from around the world. Each undergraduate student is directly supervised by a doctoral student or a postdoctoral researcher.

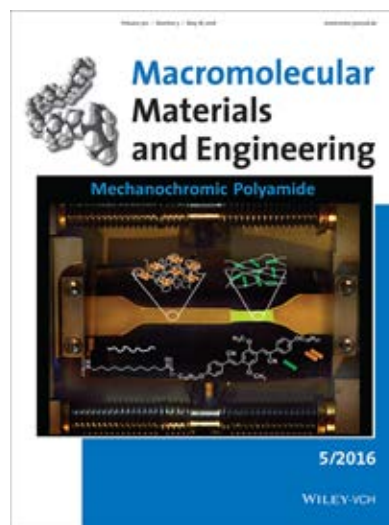
**Specialised Master in Chemistry and Physics of Soft Materials** – The NCCR has supported the launch of this new Master’s program at the University of Fribourg that is anchored by the Adolphe Merkle Institute.

**Research seminars** – The NCCR organizes a series of regular seminars with speakers from around the world. Besides learning about recent scientific advancements from prominent scientists, these seminars also serve as a meeting point for NCCR participants to network and exchange ideas.

**International Graduate Student Exchange Program** – This program provides Ph.D. students with additional experience and improves their scientific profile by awarding mobility grants that enable them to spend up to 3 months working in a laboratory abroad.

**Internal Lab Exchange** – To get insights into a different research culture, obtain an overview of the research carried at partner institutions, exchange ideas, and learn new techniques, Ph.D. candidates working on collaborative projects are expected to spend two to eight weeks working in a partner’s laboratory.

**Mobility grants** – The NCCR provides funding for its post-doctoral researchers to support stays at research institutions abroad for six to 12 months. The grant covers travel and living costs.



Adrien Holtz's student project ended up on the cover of *Macromolecular Materials and Engineering*.

## Innovation

# Finding the right partners

The National Centers of Competence in Research have a mandate to promote long-term research networks in areas of strategic importance for Swiss science, Switzerland’s economy, and society at large. To ensure an effective impact on the economy, each NCCR must lead a robust knowledge and technology transfer program.

Since its launch, the NCCR Bio-Inspired Materials has focused on how to drive innovations stemming from its research through collaborations with industrial partners. One of its first initiatives was to set up an Industrial Associates (IA) Program, created with the vision of having a core set of industrial partners who actively seek novel technologies from the NCCR’s panoply of research results.

“Successful technology transfer of basic research requires interaction between application- and product-oriented professionals with motivated academic researchers to seek innovations together,” explains Dr. Eliav Haskal, the Center’s Knowledge Transfer and Innovation Manager.

“The Industrial Associates program of the NCCR provides a platform for these groups to meet, discover and define topics of common interest, as well as seek pragmatic methods to achieve applicable results. In addition, Ph.D. students involved in the interactions get hands-on training for how to innovate, and make new contacts which can lead to employment.”

So far six industrial associates including firms such as BASF, Firmenich, and Artimelt have joined the IA program. Their benefits include receiving initial, unpublished results at an early stage, giving them a head-start on addressing innovations for their particular interests. This has already resulted in the establishment of multiple, classic research collaborations such as CTI and SATW funded projects, while other possibilities for driving innovation based on the NCCR research results are being considered.

Industrial associates may also request direct access to researchers and business professionals for brainstorming innovations, and can participate in the Center’s annual conference where they can discuss new projects. This also leads to informal meetings that can lead to hiring of NCCR researchers as employees in the aforementioned companies. Finally, the industrial associates may also benefit from specific research carried out in center laboratories through fast, NCCR-sponsored, proof-of-concept studies.





The Materials Science workshop was one KTT activity aiming to connect students with academic partners.

To date, potential applications being addressed by the NCCR's principal investigators include adhesives, sensors, anti-counterfeiting and labeling, novel production methods, advanced toxicology, targeted therapeutics, and many others. Further goals are to develop biomedical applications such as early disease detection and treatment, as well as regenerative medicine.

### Innovation

The NCCR Bio-Inspired Materials considers innovation to be of strategic importance for its development. One of the Center's specific goals is to seek applications of the research undertaken by the principal investigators that could lead to collaborations with industry. The NCCR also seeks to promote innovation culture through support to staff and by building bridges with partners pursuing similar goals.

### Other Knowledge & Tech. Transfer activities

**Company visits** – Companies are invited to meet NCCR researchers whose work could align with their own activities and to discuss potential collaborations.

**Support for translational research** – NCCR staff have received funding from the Commission for Technology and Innovation, the Swiss Academy of Engineering Sciences Transferkolleg, the Swiss National Science Foundation and the European Research Council, including for early stage research and proof-of-concept studies.

**"Life Sciences Career Day: Climb up to your dream job"** – This event was organized in collaboration with the University of Fribourg Graduate School and swissuniversities/ProDoc "Cell Migration." The day was led by the NCCR PIs Profs. Curzio Rüegg and Carole Bourquin and supported by the NCCR Operations Office, especially KTT manager Dr. Eliav Haskal. The full day event was attended by 75 Master and Ph.D. students.

**Academia-industry workshop "Materials Science Research – From Academia to Industry"** – this was organized in collaboration with the Adolphe Merkle Institute: speakers from three companies discussed their R&D challenges and methods in detail, providing insights into how research is adopted. Twelve students were also trained to present their research in five minutes, with an introduction to the subject matter, detailed research results, and specific applications/products which could benefit from the results.

# In brief

## Women in science

Once a year, the NCCR offers various modules within the Women in Science and Technology (WINS) program organized by the University of Fribourg.

This annual outreach program aims to promote traditionally male technical and scientific careers to young women at critical stages of their studies. Over two days, female high school students gain a deep overview of natural sciences and related career possibilities by visiting laboratories and interacting with young women working in those fields. The event is co-organized by female and male Ph.D. students from the Center who also hosted the participants with the support of NCCR lab technicians and senior staff.



NCCR Principal Investigator Alke Fink at the Belluard Bollwerk Festival (photo: Margaux Kolly).

## Culture

**NCCR Principal Investigator Prof. Alke Fink was invited to take part in the 2015 Belluard Bollwerk Festival in Fribourg, an annual cutting-edge contemporary arts festival, the theme of which was Fortress Europe.**

The BioNanomaterials co-chair at the Adolphe Merkle Institute took part on June 28 in an event called the Cabinet des Réalités, where she discussed “Nanoparticle and biological cell interactions” with members of the public.



## New personality

**NCCR Bio-Inspired Materials post-doctoral researcher Laura Rodriguez Lorenzo (Adolphe Merkle Institute) was named one of the French-language news magazine L’Hebdo’s 100 personalities for 2015.**

Laura is a member of the AMI BioNanomaterials team, where she is working on the modulation of the cellular uptake of nanoparticles as well as the aggregation behavior of nanoparticles in the biological environment. Laura was notably the recipient of a L’Oréal-UNESCO Fellowship “For Women in Science” in 2013 for a one-year project.

L’Hebdo, a French-language Swiss magazine, has drawn up a list every year since 2005 of the 100 people from Western Switzerland it considers the most influential. The theme for 2015 was “emerging talents,” with names selected by the editors from the fields of business, politics, culture, and science for example.

## Job sharing explained

**In May 2015, the NCCR lent its support to the Swiss Colloquium on Jobsharing in Fribourg organized by Irenka Krone-Germann, Program Manager at the Development and Trade Cooperation Section of the State Secretariat for Economic Affairs.**

The workshop was very successful with more than 200 participants from academia, industry, and politics. Principal Investigator Barbara Rothen-Rutishauser moderated a workshop about “Le jobsharing, une solution pour la relève académique?” whose panel members included her co-chair of the Adolphe Merkle Institute Bio-Nanomaterials group and Principal Investigator Alke Fink. The NCCR office together with a team of NCCR Ph.D. students and postdocs helped run the event.



The NCCR support team.



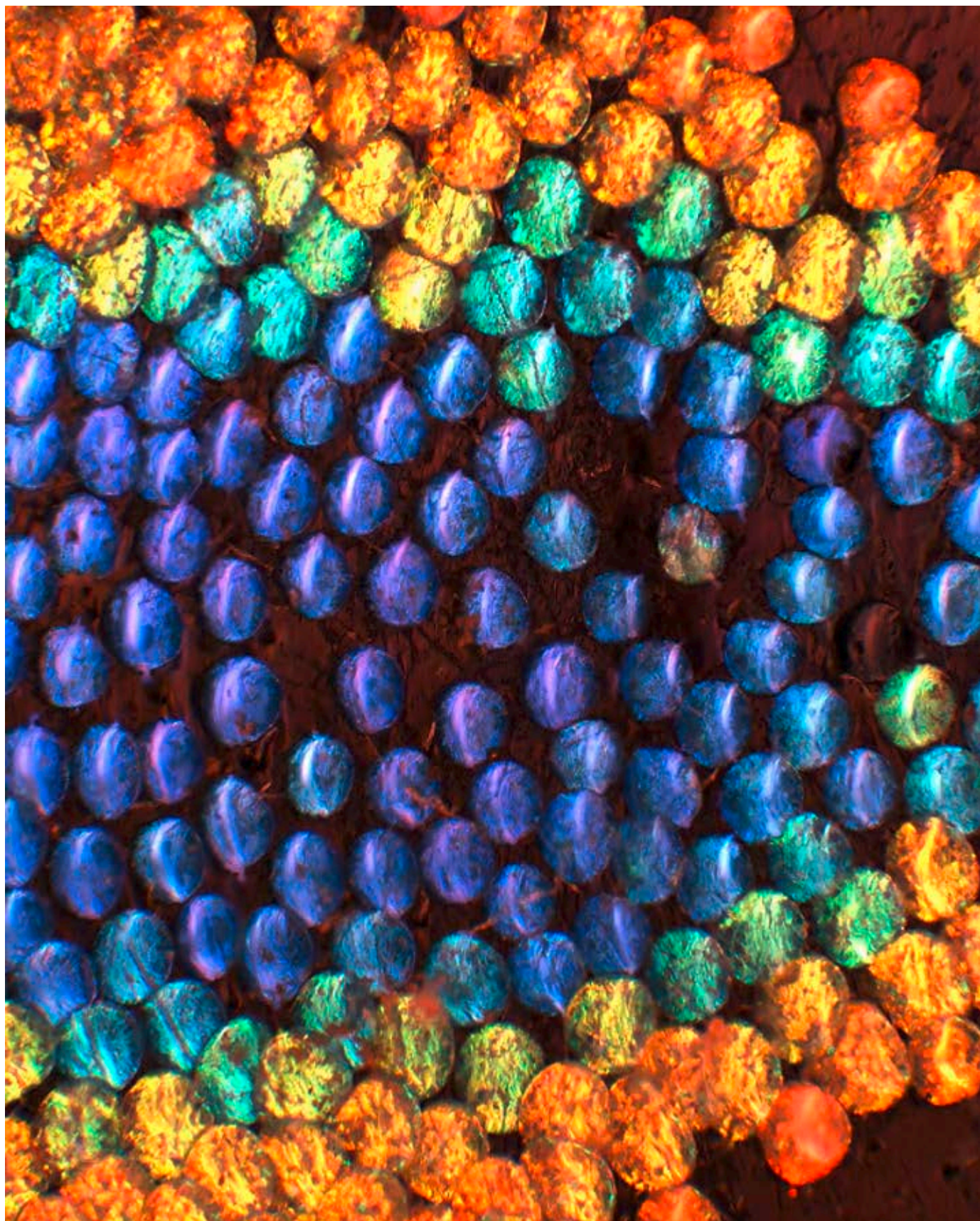
Nobel Prize winner Alan Heeger with NCCR Principal Investigator Prof. Katharina Fromm (photo: Charles Ellena/UniFR).

## Events

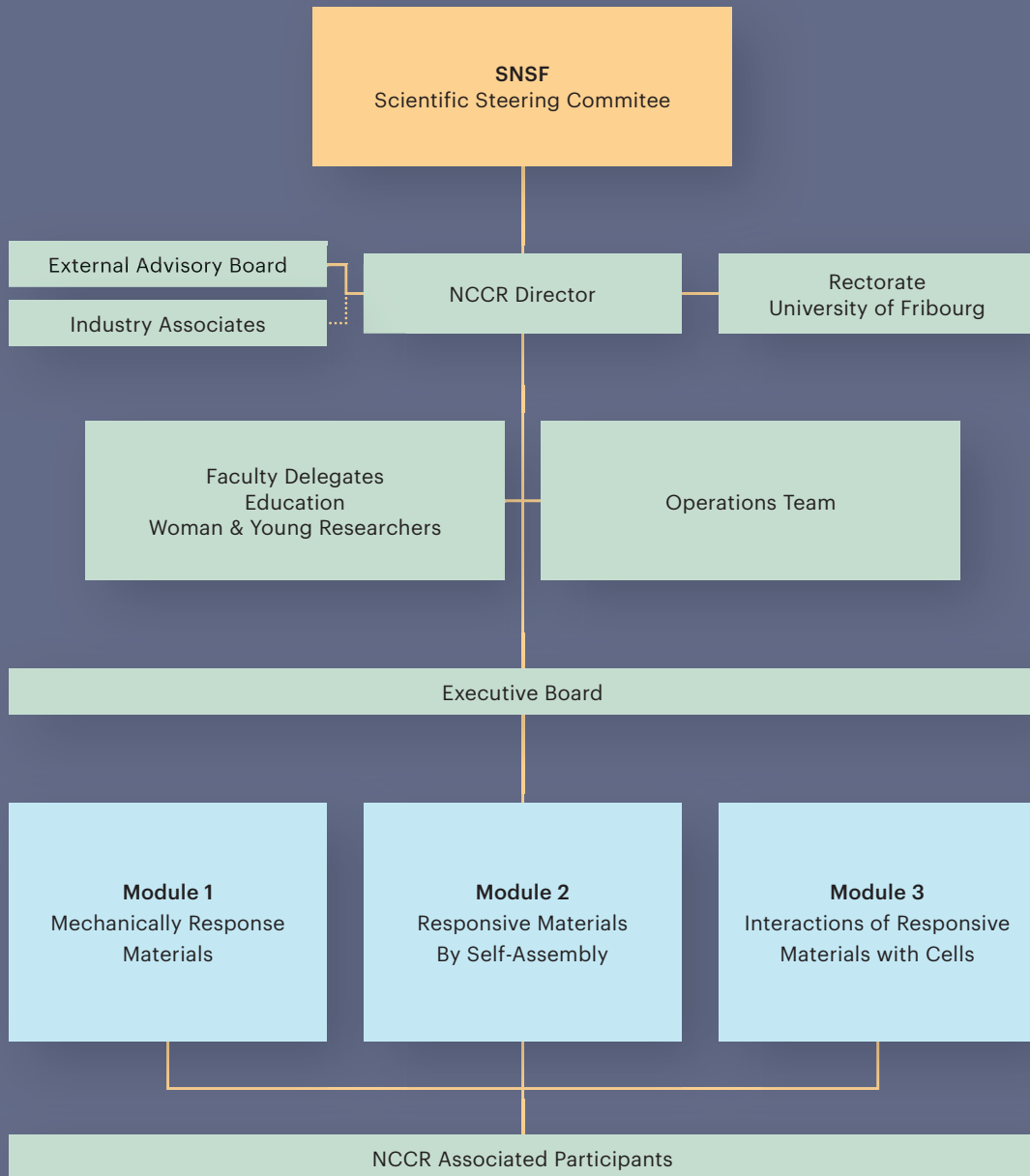
**The NCCR has actively supported, contributed and sponsored a wide range of relevant events and conferences, such as the “Fribourg Chaim Weizmann Lecture 2015” held by Prof. Alan Heeger (Nobel Prize Chemistry 2000, University of California) and the “6<sup>th</sup> International Conference on Tumor Microenvironment and Angiogenesis” in Ascona, Switzerland.**

The NCCR also endorsed the “Workshop on Advanced Light Scattering Technologies: Static and Dynamic Light Scattering” held in Fribourg in June 2015 and was present as an exhibitor at the “PolyColl 2015 – the Annual Meeting of the Division of Polymers, Colloids and Interfaces” of the Swiss Chemical Society (Fribourg, July 2015) and at the “Swiss NanoConvention 2015” in Neuchâtel in May.

In January 2016, the NCCR in collaboration with the SCOPES project Supramedchem@Balkans organized the “Imaging Techniques Workshop” in Fribourg. The workshop targeted Ph.D. students and provided introduction and training in various advanced imaging techniques such as X-ray scattering, electron microscopy, and dynamic light scattering.



# Organization



# Who is who

## Executive board

- Prof. Christoph Weder (UniFR)  
Director
- Prof. Curzio Rüegg (UniFR)  
Deputy director
- Prof. Michal Borkovec (UniGE)  
Leader Module 1
- Prof. Frank Scheffold (UniFR)  
Leader Module 2
- Prof. Alke Fink (UniFR)  
Co-leader Module 3
- Prof. Barbara Rothen-Rutishauser (UniFR)  
Co-leader Module 3, Faculty Delegate for Women and Young Researchers
- Prof. Katharina Fromm (UniFR)  
Faculty Delegate for Education 2014–2015
- Prof. Andreas Kilbinger (UniFR)  
Faculty Delegate for Education 2015
- Dr. Ana Cordeiro  
Scientific Coordinator
- Dr. Eliav Haskal  
Knowledge Transfer and Innovation manager

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- Prof. Carole Bourquin  
(Department of Medicine, UniFR)
- Prof. Joseph Brader  
(Department of Physics, UniFR)
- Prof. Nico Bruns  
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- Prof. Alke Fink  
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- Prof. Katharina Fromm  
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(Department of Medicine, UniFR)
- Prof. Frank Scheffold  
(Department of Physics, UniFR)
- Prof. Ullrich Steiner  
(Adolphe Merkle Institute, UniFR)
- Prof. Francesco Stellacci (Institute of Materials, EPFL)
- Prof. André Studart  
(Department of Materials ETHZ)
- Prof. Christoph Weder  
(Adolphe Merkle Institute, UniFR)

## Associated participant

- Prof. Andreas Zumbühl (Department of Chemistry, UniFR)

## Management

- Dr. Ana Cordeiro, Scientific coordinator
- Scott Capper, Communications officer
- Dr. Cyrille Girardin, Grant writer
- Dr. Eliav Haskal, Knowledge Transfer and Innovation manager
- Myriam Marano, Administrative assistant

## Support staff

- Dr. Sandor Balog, Senior researcher
- Véronique Buclin, Other staff
- Dr. Aurélien Crochet, Senior researcher
- Laetitia Häni, Other staff
- Dr. Dimitri Vanhecke, Senior researcher

## Research groups

### Borkovec group (UniGE)

- Prof. Michal Borkovec
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- Anne-Marie Loup, Other staff
- Dr. Plinio Maroni, Senior researcher
- Dr. Milad Radiom, Postdoctoral researcher
- Olivier Vassalli, Other staff

### Bourquin group (UniFR)

- Prof. Carole Bourquin
- Inès Mottas, Doctoral student
- Julia Wagner, Doctoral student
- Jérôme Widmer, Other staff

### Brader group (UniFR)

- Prof. Joseph Brader
- Christian Bott, Doctoral student
- Dr. Nesrin Senbil, Postdoctoral researcher

### Bruns group (UniFR)

- Prof. Nico Bruns
- Omar Rifaie Graham, Doctoral student
- Edward Apebende, Doctoral student

### Fink group (UniFR)

- Prof. Alke Fink
- Liliane Ackermann Hirschi, Other staff
- David Burnand, Doctoral student
- Federica Crippa, Doctoral student
- Leopold Daum, Doctoral student
- Dr. Laura Rodriguez-Lorenzo, Postdoctoral researcher
- Dr. Dimitri Vanhecke, Senior Researcher

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- Michela Di Giannantonio, Doctoral student
- Dr. Nelly Hérault, Postdoctoral researcher
- Anja Holzheu, Doctoral student
- Milene Tan, Doctoral student
- Serhii Vasylevskyi, Doctoral student
- Noémie Voutier, Doctoral student
- Dr. Aurelien Crochet, Other staff

### Kilbinger group (UniFR)

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- Michael Badoux, Doctoral student
- Suzanne Drechsler, Doctoral student
- Phally Kong, Doctoral student

### Lattuada group (UniFR)

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- Golnaz Isapourlaskookalayeh, Doctoral student
- Dr. Julio Cesar Martinez Garcia, Postdoctoral researcher

### Rüegg group (UniFR)

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- Grégory Bieler, Other staff
- Sarah Djahanbakhsh Rafiee, Doctoral student
- Corine Dos Santos Reis, Doctoral student
- Sanam Peyvandi, Postdoctoral researcher

### Rothen-Rutishauser group (UniFR)

- Prof. Barbara Rothen-Rutishauser
- Dr. Barbara Drasler, Postdoctoral researcher
- Daniel Hauser, Doctoral student
- Ana Milosevic, Doctoral student
- Yuki Umehara, Other staff

## Scheffold group (UniFR)

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- Dr. Luis Salvador Froufe–Pérez, Postdoctoral researcher
- Nathan Fuchs, Doctoral student
- Dr. Nesrin Senbil, Postdoctoral researcher
- Dr. Veronique Trappe, Senior researcher
- Arbnor Zenuni, Master student

## Steiner group (UniFR)

- Prof. Ullrich Steiner
- Dr. Ilja Gunkel, Postdoctoral researcher
- Mirela Malekovic, Doctoral student
- Dr. Bodo Wilts, Postdoctoral researcher

## Stellacci group (EPFL)

- Prof. Francesco Stellacci
- Simone Giaveri, Doctoral student
- Dr. Samuel Jones, Postdoctoral researcher
- Özgün Kocabiyik, Doctoral student

## Studart group (ETHZ)

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- Madeleine Grossmann, Doctoral student
- David Moore, Doctoral student
- Alessandro Ofner, Doctoral student
- Dr. Elena Tervoort, Senior researcher

## Weder group (UniFR)

- Prof. Christoph Weder
- Mathieu Ayer, Doctoral student
- Céline Calvino-Carneiro, Doctoral student
- Marc Karman, Doctoral student
- Anna Lavrenova, Doctoral student
- Laura Neumann, Doctoral student
- Dr. Stephen Schrettl, Postdoctoral researcher
- Dr. Maria Ester Verde Sesto, Postdoctoral researcher

## Zumbühl (UniFR)

- Prof. Andreas Zumbühl
- Dennis Müller, Doctoral student
- Frederik Neuhaus, Doctoral student
- Etienne Stalder, Doctoral student
- Radu Tanasescu, Doctoral student

## Alumni

- Dr. Marco Braibanti (Postdoctoral researcher, Scheffold group) 2014–2015
- Dr. Georges Bruegger (Senior scientist, Scheffold group) 2014–2015
- Dr. Davide Calzolari (Postdoctoral researcher, Scheffold group) 2014–2015
- Dr. Martin Clift (Senior scientist, Rothen-Rutishauser group) 2014–2015
- Dr. Jose Vitor De Araujo (Postdoctoral researcher, Bruns group) 2014–2015
- Dr. Jean-François Dechézelles (Senior scientist, Fink group) 2014–2015
- Dr. Florian Guignard (Doctoral student, Lattuada group) 2015
- Dr. Alexander Haehnel (Postdoctoral researcher, Weder group) 2014–2015
- Dr. David Herman (Postdoctoral researcher, Borkovec group) 2016
- Dr. You-Ting Huang (Postdoctoral researcher, Rüegg group) 2014–2015
- Manuel Kolly (Doctoral student, Steiner group) 2015
- Dr. Sonja Kracht (Doctoral student, Fromm group) 2014–2015
- Dr. Dagmar Alice Kuhn (Doctoral student, Rothen-Rutishauser group) 2014–2015
- Dr. Mariangela Mortato (Postdoctoral researcher, Fink group) 2014–2015
- Dr. Nicolas Muller (Postdoctoral researcher, Scheffold group) 2015–2016
- Dr. Simonetta Rima (Doctoral student, Lattuada group) 2015
- Dr. Yoshimitsu Sagara (Senior scientist, Weder group) 2014–2015
- Manuel Schaffner (Doctoral student, Studart group) 2014–2015



- Dr. Yoan Simon (Senior scientist, Weder group) 2014–2015
- Shun Zhao (Doctoral student, Stellacci group) 2014–2015

## Summer Students 2015

- Chris Argenti (Massachusetts Institute of Technology, USA)
- William Brenn (Case Western Reserve University, USA)
- Rachel Crane (Virginia Polytechnic Institute and State University)
- Annabelle Davey (Case Western Reserve University, USA)
- Jacob Lessard (University of New Hampshire, USA)
- Keegan Reed (Virginia Polytechnic Institute and State University)
- Alexandra Sobisch (John Carrol University, USA)
- Priya Venkatraman (Virginia Polytechnic Institute and State University)

## External advisory board

- Prof. Helmut Coelfen, Department of Chemistry, University Konstanz, Germany
- Prof. Ursula Graf-Hausner, Institute of Chemistry and Biological Chemistry, Zurich University of Applied Sciences, Switzerland
- Prof. Takashi Kato, Department of Chemistry and Biotechnology, University of Tokyo, Japan
- Prof. LaShanda Korley, Department of Macromolecular Science and Engineering, Case Western Reserve University, USA
- Dr. Christiane Löwe, Office for Gender Equality, University of Zurich, Switzerland
- Dr. Martin Michel, Food Science and Technology Department, Nestlé Research Center, Switzerland
- Prof. em. Marcus Textor, Department of Materials, ETH Zurich, Switzerland
- Prof. Marek Urban, Department of Materials Science and Engineering, Clemson University, USA

## Abbreviations

AMI: Adolphe Merkle Institute;  
UniFR: University of Fribourg;  
UniGE: University of Geneva;  
EPFL: Federal Institute of Technology Lausanne;  
ETHZ: Federal Institute of Technology Zurich

# Projects

## Module 1: Mechanically responsive materials

1. Functional polymers through mechanochemistry
2. Probing force response of single macromolecules with atomic force microscopy
3. Self-assembled biomimetic nanostructures based on stimuli-responsive block copolymers
4. Polymers with molecular auxetic behavior
5. Mechanically tunable materials through stimuli-responsive capsules

## Module 2: Responsive materials by self-assembly

6. Understanding and controlling the interactions between responsive building blocks for smart materials design
  7. Confinement induced stable liquid phases mimicking the behavior in cell membrane lipid bilayers
  8. Ultrafast stimuli-responsive color-changing hydrogels
  9. Multi-responsive photonic materials as tunable filters, sensors and switches
- AP1. Exploring vesicle-containing metallosupramolecular polymers (associated project)

## Module 3: Interactions of responsive materials with cells

10. Sensorresponsive nanoelements to detect and eliminate individual cancer cells
11. Evolving Nanoparticles
12. Magneto-responsive cell culture substrates that can be modulated in situ
13. Intelligent nanomaterials to reveal and to control their behavior in complex media, at the biointerface and in cells

# Publications

## Module 1

Antonov, L.; Deneva, V.; Simeonov, S.; Kurteva, V.; Crochet, A.; Fromm, K.M.; Shivachev, B.; Nikolova, R.; Savarese, M.; Adamo, C. Controlled tautomeric switching in azonaphthols tuned by substituents on the phenyl ring. *ChemPhysChem*, **2015**, *16*, 649.

Balkenende, D. W. R.; Coulibaly, S.; Balog, S.; Simon, Y. C.; Fiore, G. L.; Weder, C. Mechanochemistry with metallosupramolecular polymers, *J. Am. Chem. Soc.*, **2014**, *136*, 10493.

Crochet, A.; Brog, J.-P.; Fromm, K.M. Mixed metal multinuclear cr(III) cage compounds and coordination polymers based on unsubstituted phenolate: design, synthesis, mechanism and properties, *Cryst. Growth Des.*, **2016**, *16*, 189.

Dinu, M. V.; Spulber, M.; Renggli, K.; Wu, D.; Monnier, C. A.; Petri-Fink, A.; Bruns, N. Filling polymersomes with polymers by peroxidase-catalyzed atom transfer radical polymerization, *Macromol. Rapid Commun.* **2015**, 507.

Gagnon, J.; Clift, M.J.D.; Vanhecke, D.; Widnerson, I.E.; Abram, S.-L.; Petri-Fink, A.; Caruso, R. A.; Rothen-Rutishauser, B.; Fromm, K. M. Synthesis, characterization, antibacterial activity and cytotoxicity of hollow TiO<sub>2</sub>-coated CeO<sub>2</sub> nanocontainers encapsulating silver nanoparticles for controlled silver release, *J. Mater. Chem. B*, **2016**, *4*, 1166.

Haehnel, A. P.; Sagara, Y.; Simon, Y. C.; Weder, C. Mechanochemistry in polymers with supramolecular mechanophores, *Top. Curr. Chem.*, **2015**, *369*, 345.

Kokkinis, D.; Schaffner, M.; Studart, A.R. Multiscale magnetically assisted 3d printing of composite materials, *Nature Comm.*, **2015**, *6*, 8643.

Kottelat, E.; Chabert, V.; Crochet, A.; Fromm, K.M.; Zobi, F. Towards cardiolite-inspired carbon monoxide releasing molecules reactivity of d<sup>4</sup>, d<sup>5</sup> rhenium and d<sup>6</sup> manganese carbonyl complexes with isocyanide ligands, *Eur. J. Inorg. Chem.*, **2015**, 34, 5628.

Kracht, S.; Messerer, M.; Lang, M.; Eckhardt, S.; Lauz, M.; Grob ty, B.; Giese, B.; Fromm, K. M. Electron transfer in peptides: on the formation of silver nanoparticles, *Angew. Chem. Int. Ed.*, **2015**, 54, 2912.

Lavrenova, A.; Farkas, J.; Weder, C.; Simon, Y. C. Visualization of polymer deformation using microcapsules filled with charge-transfer complex precursors, *ACS Appl. Mater. Interfaces*, **2015**, 7, 21828.

Lavrenova, A.; Holtz, A.; Simon, Y.C.; Weder, C. Deformation-induced color changes in melt-processed polyamide 12 blends, *Macromol. Mater. Eng.*, **2016**, 5, 549.

Montero de Espinosa, L.; Fiore, G. L.; Weder, C.; Foster, E. J.; Simon, Y. C. Healable supramolecular polymer solids, *Prog. Polym. Sci.*, **2015**, 49, 60.

Priebe, M.; Fromm, K.M. Nanorattles or Yolk–Shell Nanoparticles—What Are They, How Are They Made, and What Are They Good For?, *Chem. Eur. J.*, **2015**, 21, 3854.

Sagara, Y.; Lavrenova, A.; Crochet, A.; Simon, Y.C.; Fromm, K.M.; Weder, C. A thermo- and mechano-responsive cyano-substituted oligo(p-phenylene vinylene) derivative with five emissive states, *Chem. Eur. J.*, **2016**, 22: 4374.

Sagara, Y.; Yamane, S.; Mitani, M.; Weder, C.; Kato, T. Mechanoresponsive luminescent molecular assemblies: an emerging class of materials, *Adv. Mater.*, **2016**, 28, 1073.

Schaefer, M.; Icli, B.; Weder, C.; Lattuada, M.; Kilbinger, A.F.M.; Simon, Y., The role of mass and length in the sonochemistry of polymers, *Macromolecules*, **2016**, 49, 1630.

Schirhagl, R.; Weder, C.; Lei, J.; Werner, C.; Textor, H.M. Bioinspired surfaces and materials, *Chem. Soc. Rev.*, **2016**, 45, 234.

Simon, Y. C.; Fiore, G. L., Weder, C. Mechanically triggered responses of metallosupramolecular polymers, *Chimia*, **2014**, 68, 666.

Weder, C., Mechanochromic polymers; In: Encyclopedia of Polymeric Nanomaterials; Kobayashi, S.; M llen, K. (Eds.); Springer Berlin Heidelberg, **2015**.

## Module 2

Br gger, G.; Froufe-P rez, L.S.; Scheffold, F.; Saenz, J.J. Controlling dispersion forces between small particles with artificially created random light fields, *Nature Comm.*, **2015**, 6, 7460

Chandler, C. J.; Wilts, B. D.; Vignolini, S.; Brodie, J.; Steiner, U.; Rudall, P. J.; Glover, B.J.; Gregory, T.; Walker, R. H. Structural colour in *Chondrus crispus*, *Sci. Rep.*, **2015**, 5, 11645.

Farage, T.F.F; Krinninger P. ; Brader J.M. Effective interactions in active Brownian suspensions, *Phys. Rev. E*, **2015**, 91, 042310.

Wilts, B. D.; Matsushita, A.; Arikawa, K.; Stavenga, D. G. Spectrally tuned structural and pigmentary coloration of birdwing butterfly wing scales, *J. R. Soc. Interface*, **2015**, 12, 20150717.

Zhang, C.; Br gger, G.; Scheffold, F. Tracking of colloids close to contact, *Opt. Express*, **2015**, 23, 22579.

Zhang, C.; O'Donovan, C.B.; Corwin, E.I.; Cardinaux, F.; Mason, T.G.; M bius, M.E.; Scheffold, F. Structure of marginally jammed polydisperse packings of frictionless spheres, *Phys. Rev. E*, **2015**, 91, 032302.

## Module 3

Anz, D.; Rapp, M.; Eiber, S.; Koelzer, V.H.; Thaler, R.; Haubner, S.; Knott, M.; Nagel, S.; Golic, M.; Wiedemann, G.M.; Bauernfeind, F.; Wurzenberger, C.; Hornung, V.; Scholz, C.; Mayr, D.; Rothenfusser, S.; Endres, S.; Bourquin, C. Suppression of intratumoral CCL22 by type I interferon inhibits migration of regulatory T cells and blocks cancer progression, *Cancer Res.*, **2015**, 75, 4483.

Balog S.; Rodriguez-Lorenzo L.; Monnier C.; Obiols-Rabasa M.; Rothen-Rutishauser B.; Schurtenberger P.; Petri-Fink A. Characterizing nanoparticles in complex biological media and physiological fluids with depolarized dynamic light scattering, *Nanoscale*, **2015**, 7, 5991.

Clift, M. J. D.; Dechézelles, J.-F.; Rothen-Rutishauser, B.; Petri-Fink, A. A biological perspective toward the interaction of theranostic nanoparticles with the bloodstream – what needs to be considered?, *Front. Chem.*, **2015**, 3, 7.

Heidegger, S.; Göbl, D.; Schmidt, A.; Niedermayer, S.; Argyo, C.; Endres, S.; Bein, T.; Bourquin, C. Immune response to functionalized mesoporous silica nanoparticles for targeted drug delivery, *Nanoscale*, **2016**, 8, 938-48.

Heidegger, S.; Jarosch, A.; Schmickl, M.; Endres, S.; Bourquin, C.; Hotz, C. Mycoplasma hyorhinis-contaminated cell lines activate primary innate immune cells via a protease-sensitive factor, *PLoS One*, **2015**, 10, e0142523.

Hirsch, V.; Kinnear, C.; Rodriguez-Lorenzo, L.; Monnier, C.A.; Rothen-Rutishauser, B.; Balog, S.; Petri-Fink, A. In vitro dosimetry of agglomerates, *Nanoscale*, **2014**, 6, 7325.

Hotz, C.; Roetzer, L.C.; Huber, T.; Sailer, A.; Oberson, A.; Treinies, M.; Heidegger, S.; Herbst, T.; Endres, S.; Bourquin, C. TLR and RLR signaling are reprogrammed in opposite directions after detection of viral infection, *J. Immunol.*, **2015**, 195, 4387.

Kinnear, C.; Balog, S.; Rothen-Rutishauser, B.; Petri-Fink, A. Thermally reversible self-assembly of nanoparticles via polymer crystallization, *Macromol. Rapid Commun.*, **2014**, 35, 2012.

Kuhn, D.; Vanhecke, D.; Michen, B.; Blank, F.; Gehr, P.; Petri-Fink, A.; Rothen-Rutishauser, B. Different endocytotic uptake mechanisms for nanoparticles in epithelial cells and macrophages, *Beilstein J. Nanotechnol.*, **2014**, 5, 1625.

Monnier, C. A.; Burnand, D.; Rothen-Rutishauser, B.; Lattuada, M.; Petri-Fink, A. Magnetoliposomes: opportunities and challenges. *European J. Nanomedicine* **2014**, 6, 201.

Moore, T.L.; Rodriguez-Lorenzo L.; Hirsch V.; Balog S.; Urban D.; Jud C.; Rothen-Rutishauser B.; Lattuada M.; Petri-Fink A. Nanoparticle colloidal stability in cell culture media and impact on cellular interactions, *Chem. Soc. Rev.*, **2015**, 44, 6287.

Piccand, M.; Bessa, J.; Schick, E.; Senn, C.; Bourquin, C.; Richter, W.F. Neonatal immune tolerance induction to allow long-term studies with an immunogenic therapeutic monoclonal antibody in mice, *AAPS J.*, **2016**, 18, 354.

Rodriguez-Lorenzo, L.; Rothen-Rutishauser, B.; Petri-Fink, A.; Balog, S. Nanoparticle polydispersity can strongly affect in vitro dose, *Part. Part. Syst. Char.*, **2015**, 32, 323.

Urban D.; Rodriguez-Lorenzo L.; Balog S.; Kinnear C.; Rothen-Rutishauser B.; Petri-Fink A. Plasmonic nanoparticles and their characterization in physiological fluids, *Colloids Surf., B*, **2016**, 137, 39.

Wick, P.; Chortarea, S.; Guenat, O.T.; Roesslein, M.; Stucki, J.D.; Hirn, S.; Petri-Fink, A.; Rothen-Rutishauser, B. In vitro-ex vivo model systems for nanosafety assessment, *Eur. J. Nanomed.*, **2015**, 7, 169.

6

**Industrial  
associates**

## Gender balance

**More than half of the NCCR  
Ph.D. students are women**

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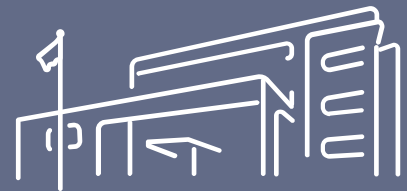
40 publications

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## Headquarters

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Adolphe Merkle Institute,  
University of Fribourg



10

**or more  
seminars per year**

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## Number projects

13

**plus one  
associate project**

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# Seminars

The NCCR organizes seminars on a regular basis throughout the academic year. These seminars are both an excellent opportunity to learn about recent scientific advances from prominent researchers as well as a meeting point for NCCR participants to network and exchange ideas.

Speaker	Talk	Home Institution	Date
Prof. Makoto Fujita	Crystalline sponge method updated: x-ray analysis without crystallization on the microgram scale	University of Tokyo, Japan	14.10.2014
Prof. Dr. Jesus M. de la Fuente	designing inorganic nanoparticles for therapy and diagnosis	University of Zaragoza, Spain	04.11.2014
Prof. Jörg C. Tiller	Design of contact-active biocidal materials and bio-switchable antimicrobial polymers	Technische Universität Dortmund, Germany	09.12.2014
Prof. Dr. Jan K.G. Dhont	Colloids in electric fields and shear flow	Forschungszentrum Jülich, Germany	10.12.2014
Prof. Hans Börner	Bio-inspired polymers: an entire world in between plastics and proteins	Humboldt Universität zu Berlin, Germany	24.02.2015
Prof. Hannes C. Schniepp	Brown recluse spider's nanometer scale ribbons of strong sticky silk	College of William & Marry, Williamsburg, VA, USA	14.04.2015
Prof. Karmen Franinovic	Active materials in design and art research	University of the Arts, Zurich, Switzerland	23.04.2015
Prof. Ulrich Wiesner	Organic-inorganic hybrids	Cornell University, Ithaca, NY, USA	29.05.2015
Prof. Thorsten Hugel	Molecular mechanisms of polymer friction and adhesion	University of Freiburg, Germany	19.06.2015
Prof. Thomas Speck	Bio-inspired materials – concepts and potential for application	University of Freiburg, Germany	22.09.2015
Claudia Nussberger	Women lead differently – is this statement right?	Partner Heidrick and Struggles, Zurich, Switzerland	20.10.2015
Dr. Emmanuel Delamarche	Tissue microprocessing using a microfluidic probe	IBM Zurich Research Lab, Rüschlikon, Switzerland	03.11.2015
Dr. Erwin Reisner	Bio-inspired hybrid materials for artificial photosynthesis	University of Cambridge, UK	12.11.2015
Dr. Silvia Vignolini	Photonic structures in nature	University of Cambridge, UK	18.11.2015
Prof. Alexandra Radenovic	2D nanopores from engineering to physics	EPFL, Lausanne, Switzerland	23.02.2016

## An annual report late in the year?

The business year of the NCCR Bio-Inspired Materials runs from June to the end of May, which explains why this report is published later in the year than most others. All statistical data are reported for March 1, in accordance with the reporting requirements of our funding agency, the Swiss National Science Foundation.

## Impressum

**Editorial:** Christoph Weder / Curzio Rüegg / Ana Cordeiro / Scott Capper **Text:** Scott Capper **Proofreading:** Annika Weder **Photos:** Pages 2, 36 Bodo Wilts / Pages 4, 34, Charly Rappo / Page 5, Shutterstock / Page 9, sciex.es / Page 11, André Studart / Page 13, Curzio Rüegg / Page 15, Marc Karman / Page 17, Inès Mottas / Page 19, Jacinthe Gagnon / Page 20, Cécile Matthey / Page 23, SwissLitho AG / Page 26, Sandor Balog / Page 34, Margaux Kolly, Belluard Bollwerk International / Page 35, Charles Ellena, UniFR / all other pictures, Scott Capper **Graphic design:** Grafikraum, Manuel Haefliger, Bern **Printer:** Imprimerie Saint-Paul, Fribourg **Copyright:** NCCR Bio-Inspired Materials, 2016



## BIO-INSPIRED MATERIALS

NATIONAL CENTER OF COMPETENCE  
IN RESEARCH

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