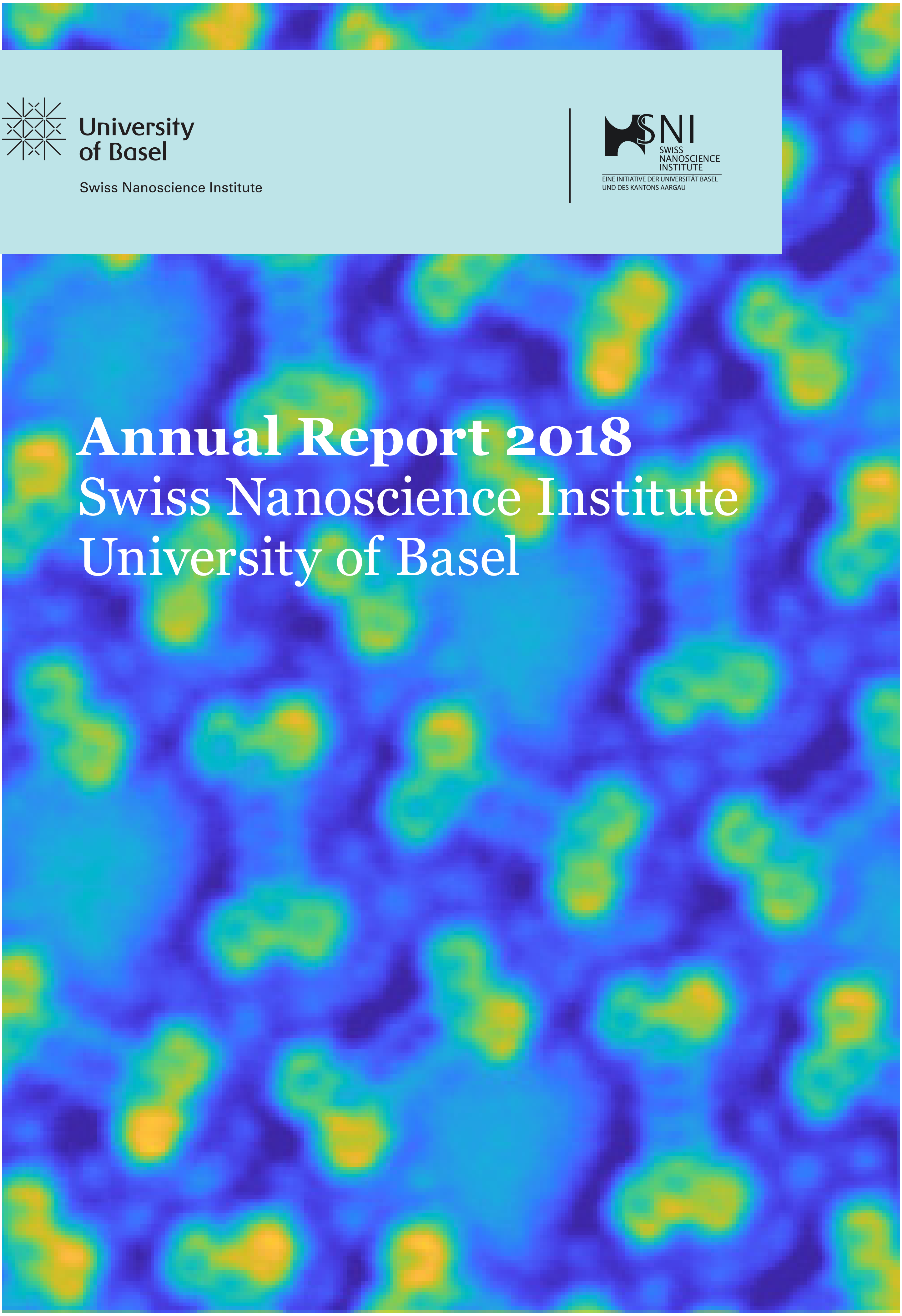
University of Basel

Swiss Nanoscience Institute

SNI
SWISS NANOSCIENCE INSTITUTE
EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU



Annual Report 2018
Swiss Nanoscience Institute
University of Basel

The Swiss Nanoscience Institute (SNI) is a research initiative of the Canton of Aargau and the University of Basel.

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Cover: Atomic force microscopic image of “nano-bone” molecules on a gold surface. The molecule is a building block for the formation of two-dimensional organic topological insulators (Rémy Pawlak, Department of Physics, University of Basel).

Content

Foreword

Dear colleagues, ladies and gentleman,

Our annual report has been streamlined and given a fresh, modern look. Moving to shorter summaries across fewer pages allows us to offer a more extensive insight into the wide-ranging fields of the scientists within the SNI network. We hope that this will provide a good overview of the highlights of 2018.

The Network section explores results obtained by researchers in the SNI network and introduces the Paul Scherrer Institute (PSI), one of SNI's important long-standing partners.

Discover more about Tino Matter's prize-winning master's thesis in the Studies section. We also report here on a symposium planned and organized by our students.

In 2018, nine young scientists completed their dissertations at the SNI PhD School. We give a brief overview of the many topics they have covered. We also summarize some of the research projects of the Argovia professors and the titular professors supported by the SNI, as well as outlining all Nano Argovia projects from 2018. Quotes from our industry partners show how valuable this program has become for various industrial companies in the region.

The SNI's Nano Imaging Lab (NI Lab) is an important partner for many research groups. The five-strong team provides an excellent imaging service, allowing customers to benefit from their many years of experience. They are also involved in educational work and assist our communications team with public relations and outreach initiatives. Some of our related activities from 2018 are described at the end of the report.

To conserve resources, we have sent the scientific supplement of the annual report only to those who supplied articles. You can access the electronic version using the QR code on the final page. We will of course be happy to send you a print copy if desired.

I hope you enjoy this wide-ranging report and look forward to your feedback. If you would like to learn more about our work at the SNI, please get in touch.

Kind regards,

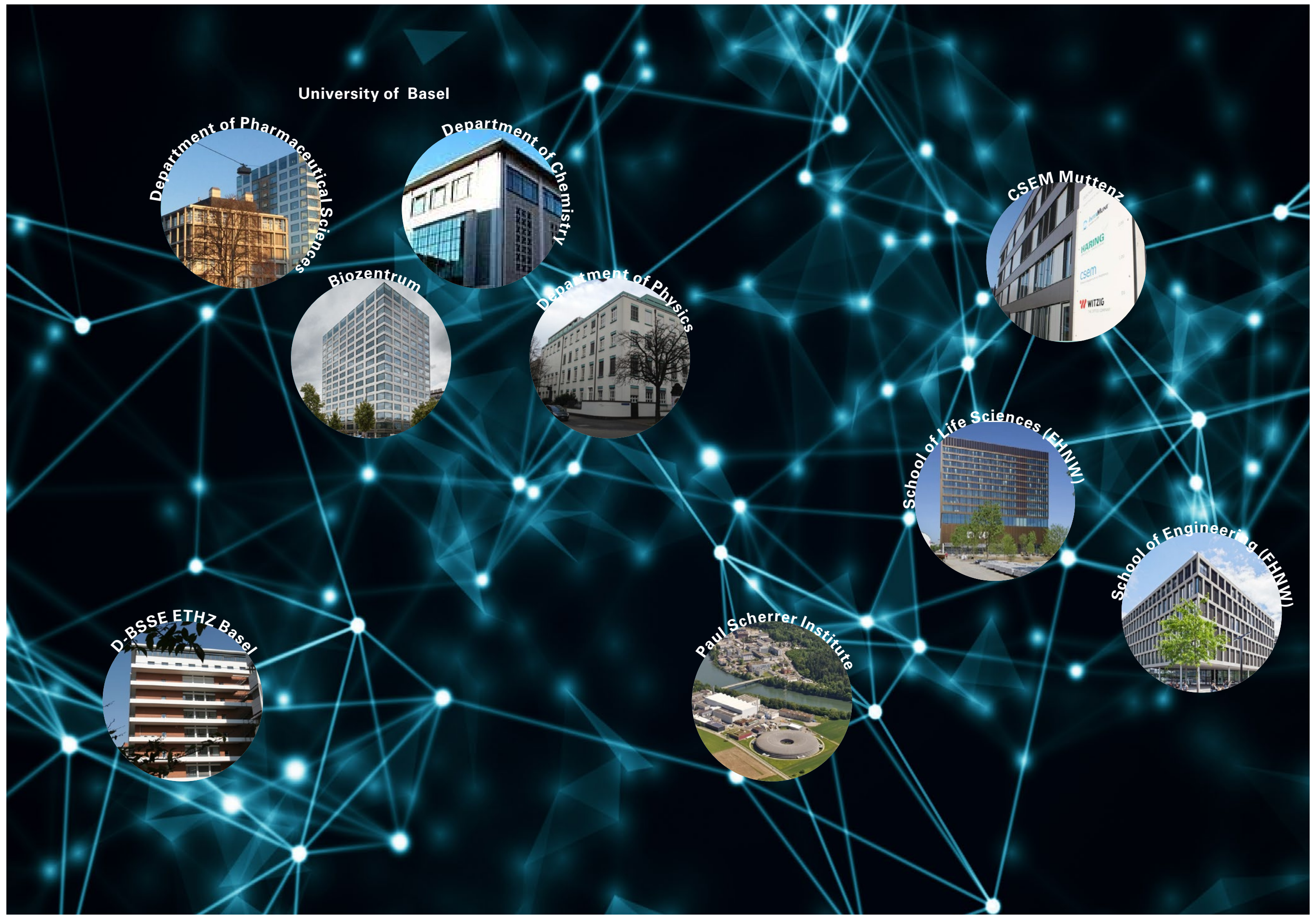
Christian Schönenberger

Christian Schönenberger
SNI Director, March 2019

Swiss Nanoscience Institute

The interdisciplinary center of excellence for nanosciences in Northwestern Switzerland

The Swiss Nanoscience Institute (SNI) at the University of Basel is a center of excellence for nanosciences and nanotechnology founded in 2006 on the initiative of the Canton of Aargau and the University of Basel. In the SNI network, interdisciplinary teams of scientists conduct basic and applied research that actively supports knowledge and technology transfer with industrial companies from Northwestern Switzerland as part of the Nano Argovia program. The SNI's Nano Imaging Lab offers a comprehensive imaging service for companies and research institutions. The SNI provides interdisciplinary training for young scientists through a bachelor's and master's study program in nanoscience and the PhD School. The SNI is also involved in public relations activities and specifically supports initiatives aiming to interest various target groups in the natural sciences and support collaboration between academia and industry.



The SNI's success is based on its interdisciplinary network of leading research institutions in Northwestern Switzerland. (Background image: Shutterstock)

Commitment from the Canton of Aargau

The SNI was founded in 2006 by the Canton of Aargau and the University of Basel to promote research and training in the nanosciences and nanotechnology in Northwestern Switzerland. Aargau's economy is highly industrial, making nanotechnologies extremely relevant to research and industry. The SNI's many successful research projects, in which researchers from various disciplines and institutions work together, support the high-tech strategy of the Canton of Aargau and provide companies from Aargau and the two Basel half cantons with access to new scientific findings and technologies. In 2018, the SNI had a total budget of 7.25 million Swiss francs, of which 4.5 million came from the Canton of Aargau and 2.75 million from the University of Basel.

A diverse, active network

The success of the SNI is based on the interdisciplinary network that has been built up over the years and is constantly attracting new members. This network includes the Departments of Chemistry, Physics, Pharmaceutical Sciences, and Biozentrum at the University of Basel, research groups in the School of Life Sciences and School of Engineering at the University of Applied Sciences Northwestern Switzerland (FHNW) in Muttenz and Windisch, the Paul Scherrer Institute, the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel, and the Centre Suisse d'Electronique et de Microtechnique (CSEM) in Muttenz. The wider network includes the Hightech Zentrum Aargau in Brugg and BaselArea.swiss, which promote knowledge and technology transfer.

Excellent education for students

The University of Basel has offered bachelor's and master's programs in nanosciences since 2002. At the end of 2018, 52 students were enrolled on the bachelor's program and 45 young researchers were enrolled on the master's program. The bachelor's program provides a solid basic education in biology, chemistry, physics, and mathematics. As this demanding program progresses, students can choose from a wide range of practical and theoretical courses that allow them to focus on specific topics. Early on in their education, they have the opportunity to participate in various research groups and to gain an insight into industrial research projects.

A variety of topics at the PhD School

To promote the further training of young scientists and a wide spectrum of basic scientific research, the SNI initiated a PhD School in 2012. All doctoral students at the SNI PhD School are supervised by two members of the SNI network. The interdisciplinary education is enhanced by the participation of doctoral students in internal scientific events such as the Winter School "Nanoscience in the Snow", the Annual Meeting, and various courses specially developed for the PhD School. In 2018, 41 doctoral students were enrolled, nine of whom completed their dissertations. Eight new projects were approved that will begin in 2019.

Leaders in their field

Basic sciences form the foundation of research work at the SNI. In addition to the various projects funded as part of the PhD School, the SNI also supports the basic scientific research performed by Argovia professors Roderick Lim and Martino Poggio. Through their work, both contribute to the SNI's outstanding international reputation. The SNI also supports three titular professors: Professor Thomas Jung teaches and works at the Department of Physics at the University of Basel and leads a team at the PSI. Professors Frithjof Nolting and Michel Kenzelmann also lecture at the Department of Physics and are active with their research groups at the PSI.

Strong connections to practical application

The transfer of academic findings to industry plays a key role at the SNI and is supported by the Nano Argovia program. In 2018, seven new projects were approved and four projects from the previous year were extended. Partner companies from the Canton of Aargau were involved in six projects, along with five companies from the two Basel half cantons.

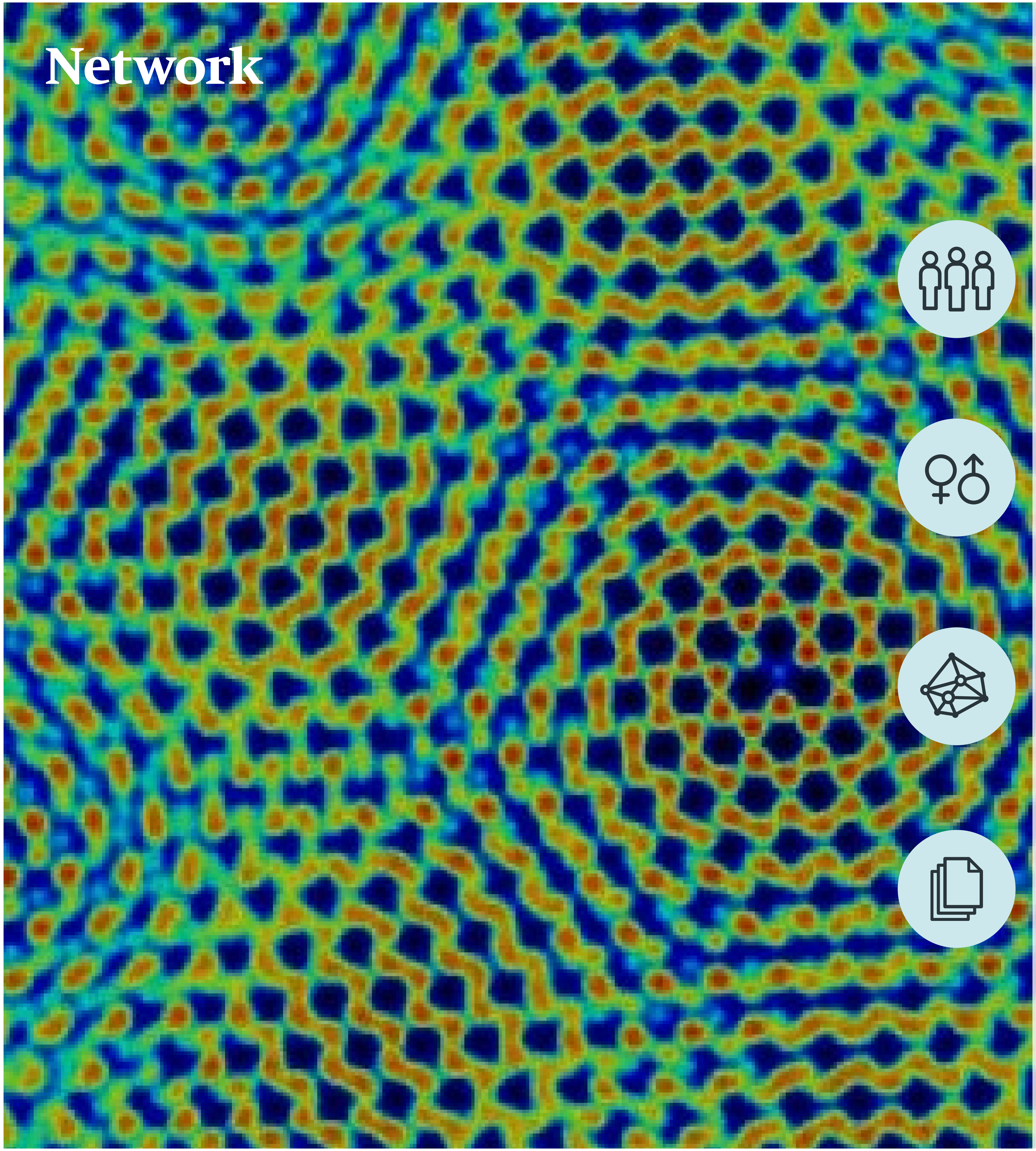
Services in demand

The SNI also provides its academic and industrial partners with various services. These services center on the Nano Imaging Lab (NI Lab), which was founded in 2016. The five NI Lab team members have a wealth of experience in electron and scanning probe microscopy and offer a comprehensive imaging service thanks to their outstanding facilities and expertise. The SNI also supports the excellently equipped workshops for technology, electronics, and mechanics in the Department of Physics. Research institutions and industrial companies can access both the expert knowledge of the staff as well as the outstanding technical resources of the SNI and affiliated departments.

Sharing the fascination with others

The SNI believes it is important to inform the public about its activities and to involve them in its fascination with the natural sciences. For example, the SNI team is actively involved in science festivals and exhibitions and provides schools and groups of interested visitors with an insight into everyday laboratory life. The SNI uses its newsletter, press releases, webpage, LinkedIn page, and various brochures to share outstanding research results and reports on activities with various target groups. Two Nano-Tech Apéro receptions were held in 2018 to promote interaction between industry, business, and science.

Network



145

145 members belong to the SNI network.

22%

22% of the SNI members are women.

8

There are eight partner institutions in the SNI network. These include the research institutions University of Basel, the School of Life Sciences at the University of Applied Sciences Northwestern Switzerland (FHNW), the School of Engineering at the FHNW, the Paul Scherrer Institute (PSI), the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel, and the Centre Suisse d'Electronique et de Microtechnique (CSEM) in Muttenz. The network also includes the Hightech Zentrum Aargau and BaselArea.swiss.

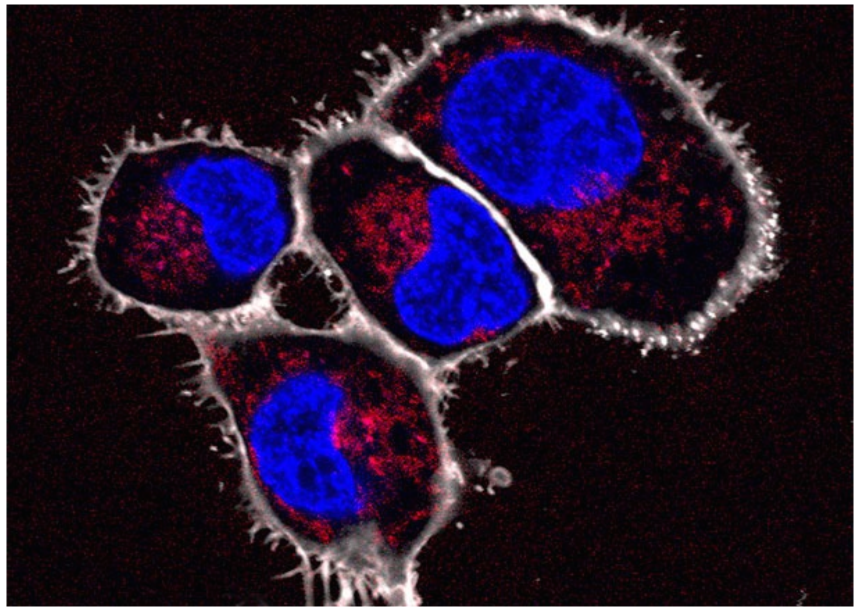
58+181

SNI members published 58 scientific papers based on SNI projects and presented their work as part of 181 talks at national and international conferences.

Illustration of the periodic potential structure that forms when a single layer of carbon atoms (Graphene) is combined with two layers of Boron Nitride, one on top, one at the bottom, at different angles. Effects of such artificial crystal structures can be found in electronic devices fabricated in the Nano-electronics group at the University of Basel. (Image: Andreas Baumgartner, Department of Physics, University of Basel)

News from the network

As the examples below demonstrate, scientists from the SNI network study a wide range of topics. In 2018, they published 58 articles in renowned scientific journals on the basis of SNI projects, and a number of network partners received awards for their scientific work.



A fluorescence reaction reveals artificial organelles at work in the scavenger cells of a zebrafish. (Image: Department of Pharmaceutical Sciences, University of Basel)

Tiny implants for cells are functional in living organisms
For the first time, an interdisciplinary team from the University of Basel has succeeded in introducing artificial organelles into the cells of live zebrafish embryos. This innovative approach using artificial organelles as cellular implants raises new prospects for treating a range of diseases, as the authors reported in their publication in "Nature Communications".

"The findings of scientists from the SNI network attract considerable attention from the international scientific community and offer excellent potential for innovation."

Prof. Torsten Schwede, Vice President for Research at the University of Basel and member of the SNI Board

Einstein-Podolsky-Rosen paradox observed in many-particle system for the first time
Physicists from the University of Basel have observed the quantum mechanical Einstein-Podolsky-Rosen paradox in a system of several hundred interacting atoms for the first time.

The phenomenon dates back to a famous thought experiment in 1935. It allows the precise prediction of measurement results and could have applications in new types of sensors and imaging methods for electromagnetic fields, as the researchers reported in the journal "Science".

The motor for molecular factories is running
An interdisciplinary team from the University of Basel, the University of Bern and ETH Zurich have succeeded in inserting the proton pump proteorhodopsin into tiny vesicles – enclosed in a synthetic polymer membrane – for the first time. By doing so, the researchers created an efficient energy source for an artificial molecular factory. In another first, they supported their experiments with statistical design and took quantitative measurements, creating an excellent basis for further optimization and expansion of the concept, as they reported in the journal "Nature Communications Chemistry".

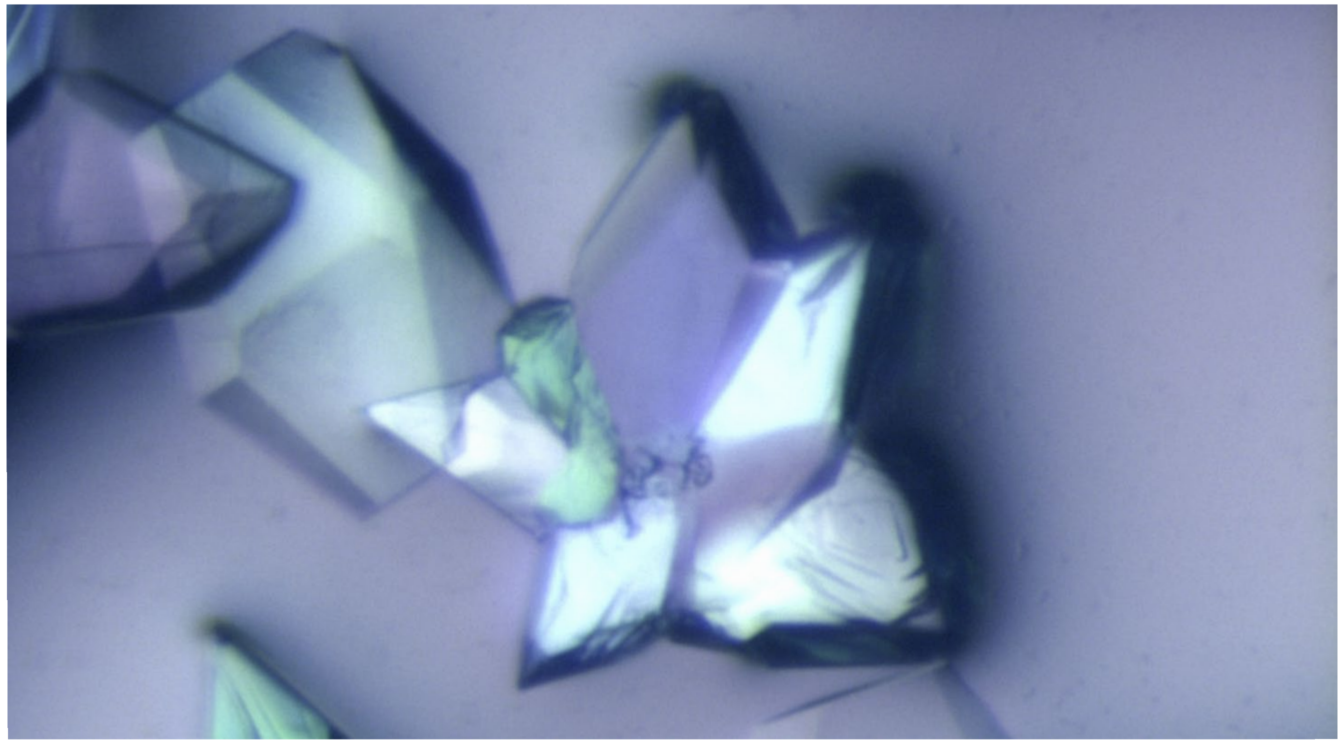
Novel approach to coherent control of a three-level quantum system
For the first time, researchers have succeeded in studying quantum interference in a three-level quantum system and thus in controlling the behavior of individual electron spins. To this end, they used a novel nanostructure in which a quantum system was integrated into a nanoscale mechanical oscillator in the form of a diamond cantilever. The study was conducted by scientists from the University of Basel and the Swiss Nanoscience Institute and was published in "Nature Physics".

Imaging the inside of injection needles with neutrons
Researchers from the Paul Scherrer Institute (PSI), the University of Basel and the company F. Hoffmann-La Roche have discovered why it is vital for prefilled syringes of liquid medications to be kept refrigerated. Thanks to the special neutron imaging capability established at the PSI, it was clear: When the prefilled syringe is stored at excess temperatures, the liquid active agent in the syringe cylinder can unintentionally pass into the metal needle prior to administration. The findings were published in the "European Journal of Pharmaceutics and Biopharmaceutics".

"The SNI network is a pool of highly qualified specialists in the areas of nanophysics, nanochemistry, and nanobiology."

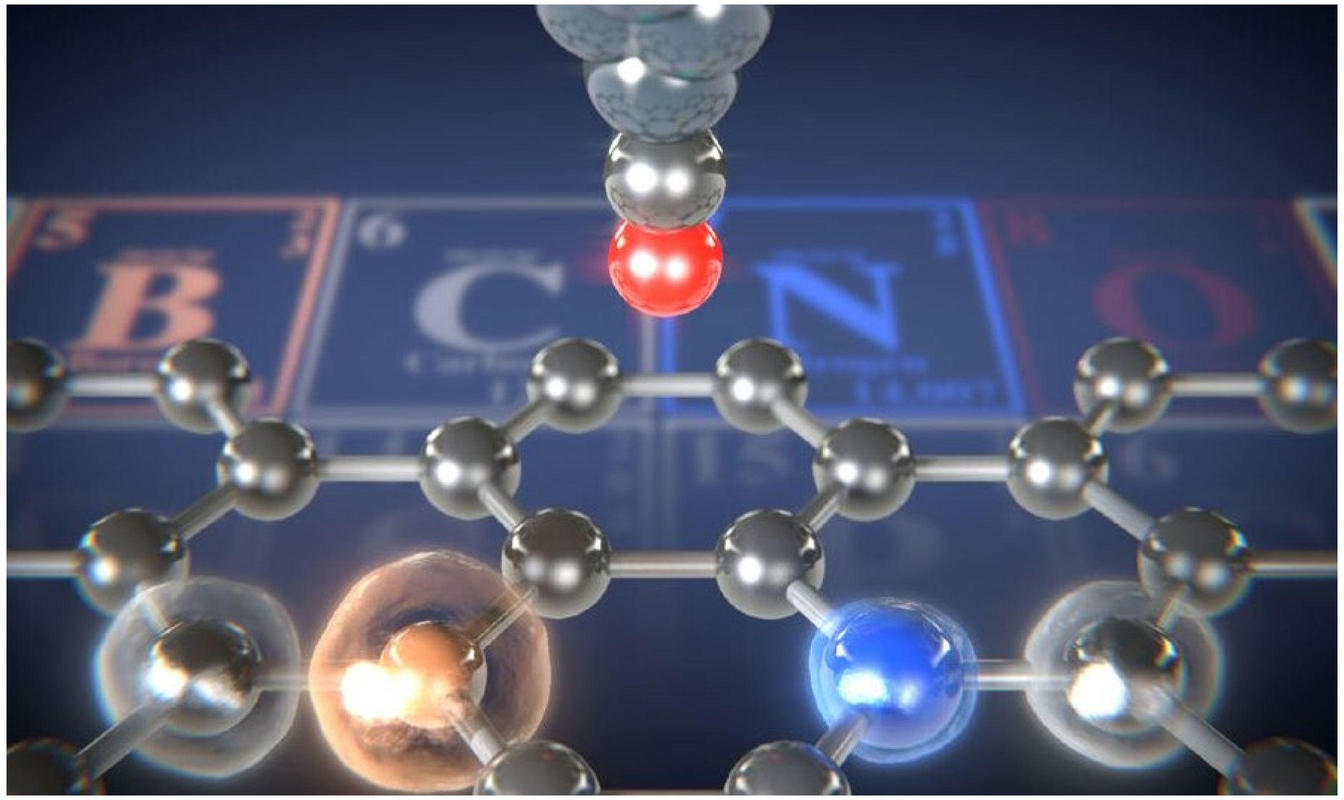
Dr. Martin Bopp, Managing Director at the Hightech Zentrum Aargau

No damage to protein crystals
The development of the X-ray free-electron laser has allowed rapid analysis of biological macromolecules, such as proteins, based on electron diffraction by atoms inside the molecule. Now, an international team led by scientists from the Biozentrum at the University of Basel and the Paul Scherrer Institute (PSI) has shown that the ultrashort X-ray pulses used to irradiate samples do not cause significant damage to protein crystals. These pulses last just a few femtoseconds (1 femtosecond = 1 x 10^{-15} seconds). As the researchers reported in the journal "Structural Dynamics", the chosen conditions are suitable for studying the dynamics of protein crystals.



Ultrashort X-ray pulses lasting a few femtoseconds do not cause significant damage to protein crystals. (Image: Nadia Opara et al., J. Appl. Cryst. (2017), https://doi.org/10.1107/S1600576717005799)

Individual impurity atoms can be detected in graphene
A team including physicists from the Department of Physics and the Swiss Nanoscience Institute at the University of Basel has succeeded in using atomic force microscopy to obtain clear images of individual impurity atoms in graphene ribbons. By measuring forces in the graphene's two-dimensional carbon lattice, the researchers were able to identify boron and nitrogen for the first time, as they reported in the journal "Science Advances".



The carbon monoxide functionalized tip (red/silver) of the atomic force microscope can be used to measure the forces between the tip and the various atoms in the graphene ribbon. (Image: Department of Physics, University of Basel)

"Cutting-edge research within the SNI network provides opportunities for technological innovation."

Prof. Magnus Kristiansen, School of Engineering at the University of Applied Sciences Northwestern Switzerland and member of the SNI Board

Water-soluble chains
In a publication in "Chemistry – A European Journal", chemists from the University of Basel have described a new synthesis route to so-called "daisy chains" in aqueous solution. For this, they have developed a ring-shaped molecule and a molecular axle, which spontaneously organize themselves into a supramolecular rotaxane (an axle threaded through a ring). In the basic building block of the daisy chain, the axle and the ring are firmly connected to one another, so the molecules can only form a rotaxane in pairs: The axle of the first molecule runs through the ring of the second, while the axle of the second molecule sits inside the ring of the first. As the two molecules are mechanically connected by virtue of their topology, they are able to move around relative to one another. Supramolecular systems of this kind are of great interest as model systems for molecular machines.

Miniaturized sample preparation for electron microscopy
A team of scientists from the C-CINA (Biozentrum) and the Swiss Nanoscience Institute has developed an effective sample-preparation method tailored to the needs of cryo-electron microscopy. For this, the researchers use a microfluidic system requiring only a few nanoliters of sample material. In the new technique, the samples are handled very gently and are available for analysis in a significantly shorter period of time. As the scientists reported in the "Journal of Visualized Experiments", the small quantity of sample material required also paves the way for entirely new strategies such as single-cell analysis.

Collisions in the trap
Scientists from the Department of Chemistry and the Swiss Nanoscience Institute at the University of Basel have developed an ion trap in which they have studied the interaction of individual ions with a gas made up of neutral atoms at temperatures below one millikelvin (<-273.149°C).

In normal circumstances, individual particles reach thermal equilibrium with their environment. In the study, however, the researchers showed that the ions possess considerably more energy after colliding with the ultracold atoms and that the energy of the ions does not correspond to a thermal distribution.

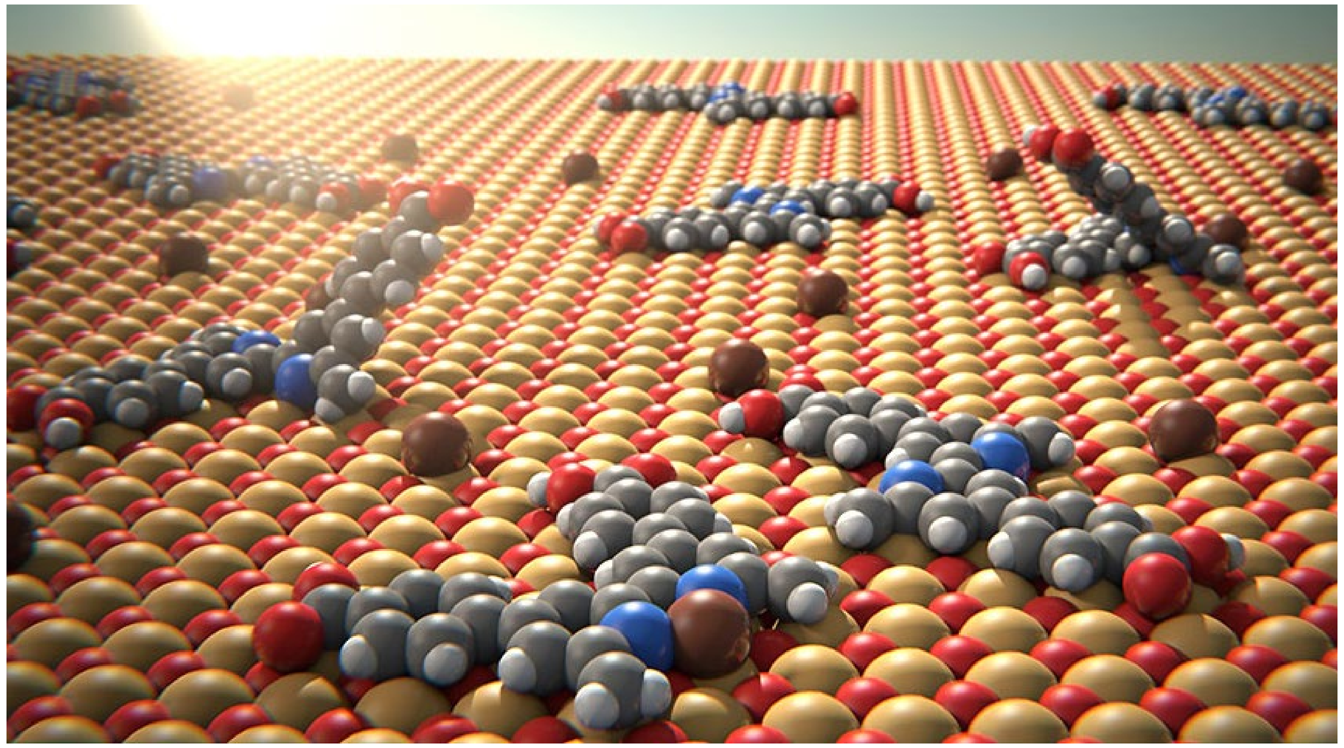
So-called "Tsallis statistics" can provide an initial approximation of the energy distribution even if external forces such as electric fields are acting on the ion trap, as the researchers reported in the journal "Physical Review Letters".

Experiments of this kind involving ultracold atoms are useful for clarifying fundamental concepts of chemical reactions because the low temperatures, which are close to absolute zero, bring about a reduction in the kinetic energy.

"The SNI has established itself as a center of excellence in research and teaching, and also provides an ideal platform for companies to access and benefit from nanoscience research."

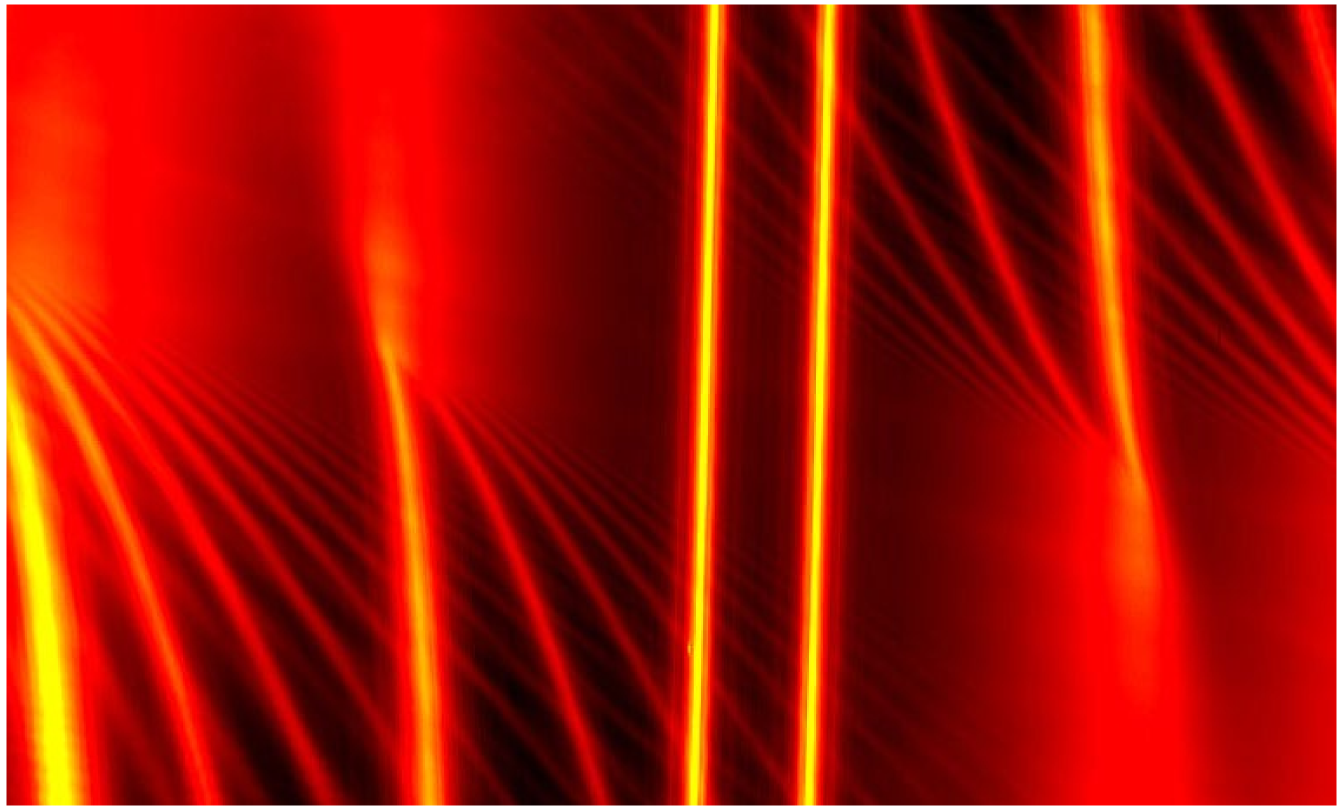
Prof. Joël Mesot, President of ETH Zurich, former director of the PSI and member of the Argovia Board

Metal leads to desired configuration
Scientists from the network of the Swiss Nanoscience Institute at the University of Basel have found a way to change the spatial arrangement of bipyridine molecules on a surface. These potential components of dye-sensitized solar cells form complexes with metals and thereby alter their chemical conformation. The results of this interdisciplinary collaboration between chemists and physicists from Basel were published in the journal "ACS Omega".



Scientists were able to determine the spatial arrangement of bipyridine molecules (gray) on a surface of nickel and oxygen atoms (yellow/red). Rotation changes the trans configuration (front right) to a cis configuration (front left). (Image: Department of Physics, University of Basel)

Probing individual edge states with unprecedented precision
For the first time, a new technique has allowed researchers to obtain an individual fingerprint of current-carrying edge states, such as those occurring in novel materials such as topological insulators or 2D materials. Physicists from the University of Basel presented the new method in "Nature Communications" in collaboration with American scientists. The fan-like patterns of red/yellow curves correspond to a fingerprint of the conducting edge states, each of which is represented by an individual curve.



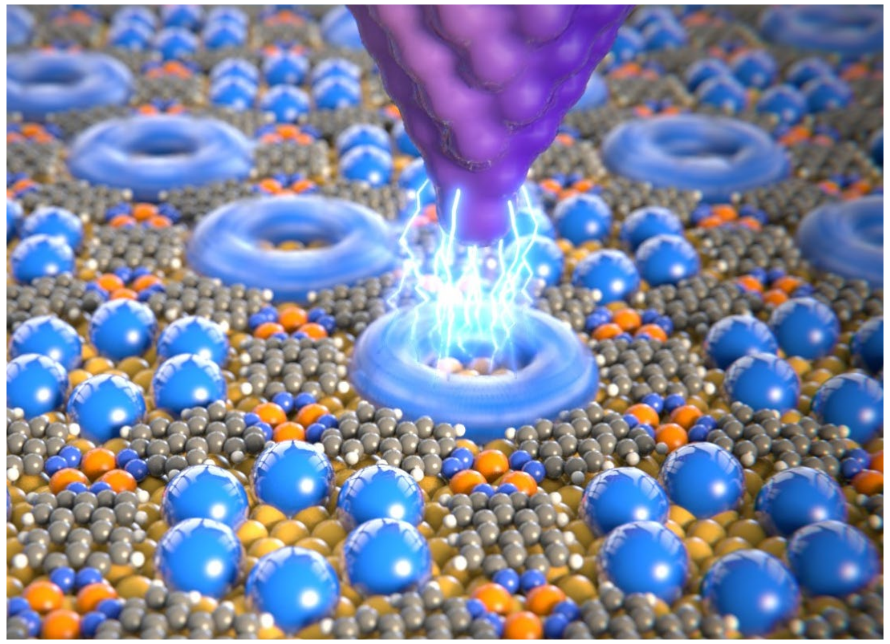
Measured tunneling current and its dependence on the two applied magnetic fields: The fan-like patterns of red/yellow curves correspond to a fingerprint of the conducting edge states, each of which is represented by an individual curve. (Image: Department of Physics, University of Basel)

New mechanism of electron spin relaxation observed
Physicists at the University of Basel want to use the spin of an individual electron confined in a semiconductor nanostructure as a unit of information for future quantum computers. Their experiments have now provided the first proof of a mechanism of electron spin relaxation that was predicted 15 years ago. The scientists also managed to keep the direction of the electron spin fixed for almost a minute – a new record.

The results of this collaboration with researchers from Japan, Slovakia and the USA were published in "Nature Communications".

Electron beams reveal the three-dimensional structure of nanocrystals
In a collaboration with the companies Dectris Ltd. (Baden) and Crystallise! AG (Schlieren), and with support from the Swiss Nanoscience Institute (SNI), researchers from the Paul Scherrer Institute, ETH Zurich and the University of Basel have shown that electron beam diffraction is ideally suited to determining the three-dimensional structure of crystals. Providing a complement to the technique of X-ray crystallography, the method delivers reliable results even with crystals in powder form and with sizes ranging from just ten to a few hundred nanometers across. The scientists published the results of the study, which was carried out as part of the Nano Argovia program, in the journal "Angewandte Chemie".

Data storage using individual molecules
Researchers from the SNI network at the University of Basel have reported a new method that allows them to control the physical state of just a few atoms or molecules within the pores of a network. The method is based on the spontaneous self-organization of molecules into extensive networks with pores measuring about one nanometer in size. As the physicists report in the journal "small", the experiments could have significant implications in the development of new storage devices.



Computer-generated animation of a potential data storage device on the atomic scale: A data storage element – made up of just six xenon atoms – is liquefied using a voltage pulse. (Image: Department of Physics, University of Basel)

> "Scientists from the SNI network win awards and attract national and international third-party funding for their innovative research."

Prof. Andrea Schenker-Wicki, President of the University of Basel and member of the SNI Argovia Board

Daniel Riedel receives Quantum Future Award
Dr. Daniel Riedel has been awarded the Quantum Future Award from the Federal Ministry of Education and Research in Germany (BMBF) and the Center for Integrated Quantum Science and Technology (IQST). Daniel, who completed his doctoral thesis at the SNI PhD School in December 2017, won second prize in the "dissertations" category.

Basel-based startup Qnami wins Venture Kick finals
The Venture Kick funding initiative has awarded a prize worth 130,000 Swiss francs to Qnami, a young start-up from the University of Basel and the SNI network. Qnami develops precise and highly sensitive quantum sensors that produce images in nanometer resolution.

Millions of euros in EU funding for Christian Schönenberger
The European Research Council (ERC) has awarded an ERC Advanced Grant to Professor Christian Schönenberger, Director of the Swiss Nanoscience Institute, who is also an experimental physicist at the University of Basel's Department of Physics. Schönenberger is one of the few scientists whose groundbreaking research has received an ERC Advanced Grant for the second time. In 2018, he was awarded around 2.9 million Swiss francs for his research project on the superconductivity of van der Waals heterostructures.

Quantum Technologies Flagship launched with participation by three Basel research groups
In November 2018, the European Commission launched its flagship initiative for research into quantum technologies. Participants include three research groups from the SNI network, which are based at the University of Basel's Department of Physics.

This billion-euro research and technology funding program aims to develop radically new and powerful quantum technologies by exploiting a variety of quantum effects.

The Paul Scherrer Institute
30 years old and a key partner in the SNI network

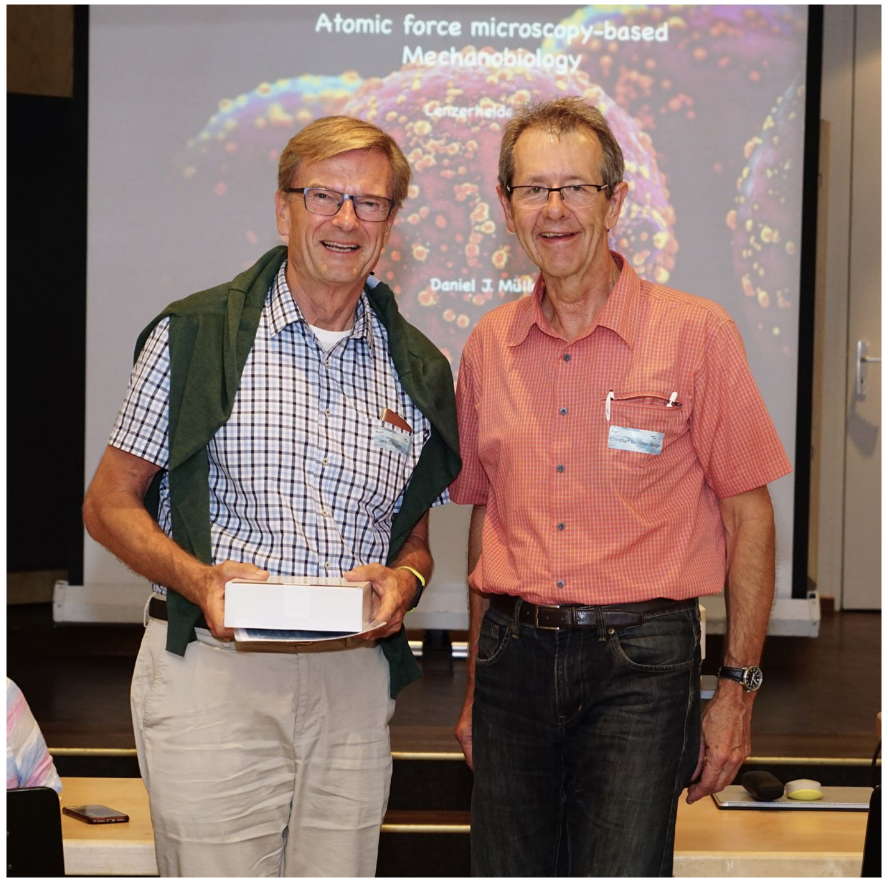
In October 2018, the Paul Scherrer Institute (PSI) in Villigen celebrated its 30th anniversary and demonstrated what a valuable contribution the Institute has made to science and society since its establishment. Scientists from the PSI are also valuable partners for the Swiss Nanoscience Institute (SNI). They lend their expertise by acting as titular professors and project leaders in the Nano Argovia program and the PhD School while also benefiting from scientific exchange within the SNI network.

It is its large research facilities predominantly that make the Paul Scherrer Institute (PSI) unique throughout Switzerland and allow it to adopt a leading role worldwide. For example, the PSI provides researchers from universities and industry with access to the Swiss Light Source (SLS) or the SwissFEL X-ray free-electron laser, allowing them to gain a completely new and unique insight into the world of atoms and molecules.

New discoveries thanks to the SLS and SwissFEL
The Swiss Light Source (SLS) gives off a particularly intense and highly bundled form of light, whose wavelength can be adjusted precisely between those of UV light and X-rays. It is emitted by electrons moving on a circular path at nearly the speed of light, and the ability to adapt the light to various requirements allows scientists to study a wide range of materials. For example, they can determine the structure of complex proteins using tiny crystals, apply colored marking to areas of different magnetization in magnetic materials, or create detailed 3D visualizations of the inside of objects.

The latest large research facility at the PSI, the SwissFEL X-ray free-electron laser, adds to the broad spectrum of applications. By emitting very short pulses of X-rays with laser properties, the SwissFEL even allows researchers to track chemical reactions and the formation of new molecules.

For many years, the Paul Scherrer Institute has been an important partner in the SNI network. (Image: Paul Scherrer Institute)



In 2018, Jens Gobrecht was made an honorary member of the SNI.

"Since the foundation of the SNI, the PSI has been a valuable partner in the network. Jens Gobrecht has played a vital role in supporting this collaboration and has therefore been awarded honorary membership of the SNI."

Prof. Christian Schönenberger, SNI Director, University of Basel

Collaboration through Nano Argovia and the PhD School
Scientists from the PSI participate actively in the SNI network and benefit from a regular exchange of ideas through the SNI PhD School and the Nano Argovia program. So far, eleven SNI PhD students have had a supervisor at the PSI and almost 60 percent of all Nano Argovia projects have involved scientists from the Paul Scherrer Institute.

It was primarily Professor Jens Gobrecht who initiated many of the projects in the early years of the SNI, and for many years he acted as a point of contact for all questions relating to the Nano Argovia program. In honor of this enormous commitment, he was made an honorary SNI member at the SNI's Annual Event in September 2018.

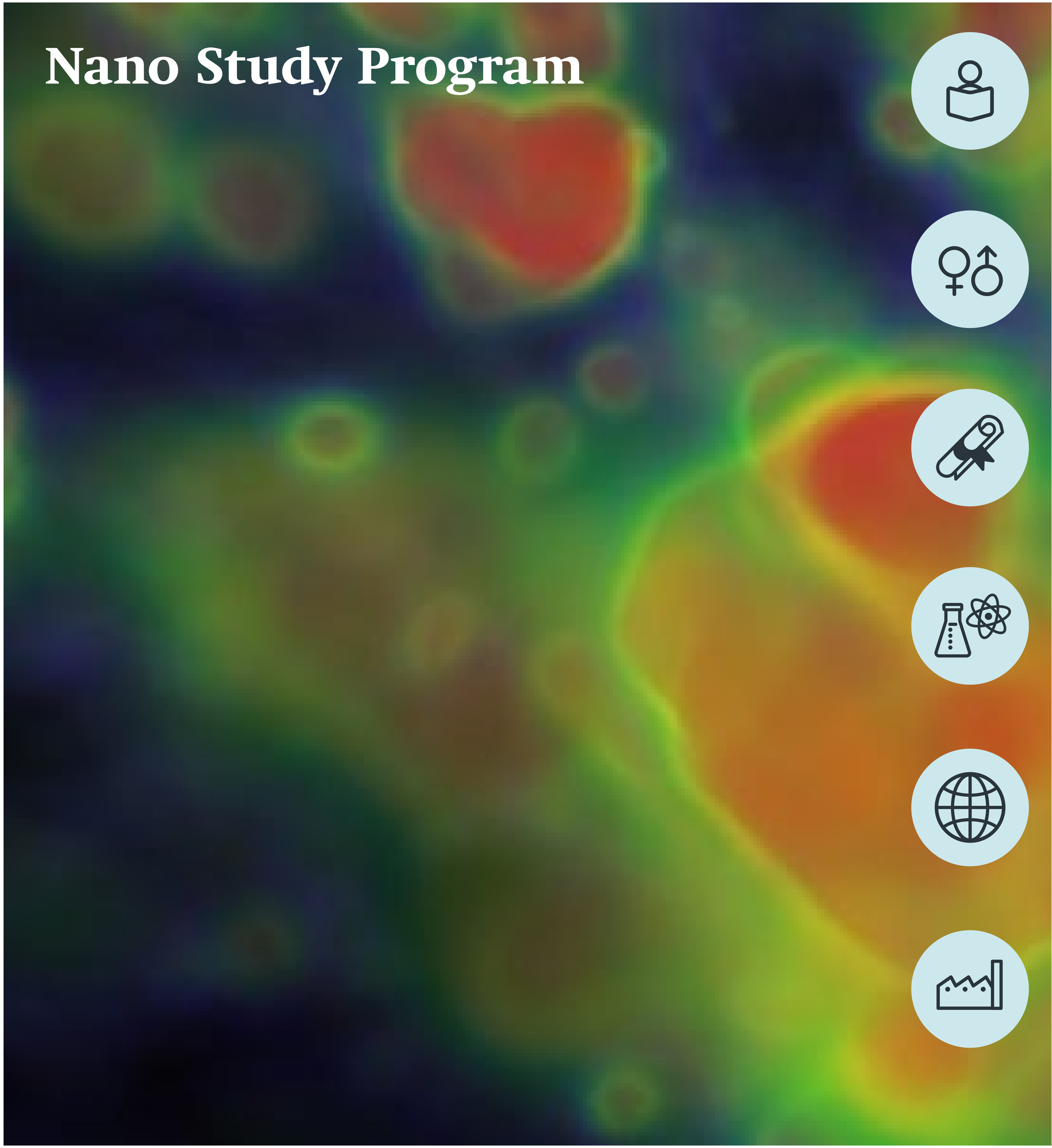
"We also have Jens Gobrecht to thank for the Laboratory for Micro and Nanotechnology (LMN) at the PSI, which is actively used by members of the SNI network and provides young students on the nanosciences degree program with their first opportunity to witness nanofabrication in a professional cleanroom," says Professor Christian Schönenberger, Director of the SNI.

Titular professors at the University of Basel
The excellent cooperation within the SNI network also benefits from the contributions of the three titular professors Thomas Jung, Michel Kenzelmann and Frithjof Nolting, who supervise research groups at the PSI and teach at the University of Basel. Professor Thomas Jung, who also leads a working group at the University of Basel's Department of Physics, says: "For me and my team, it's amazing to have access to colleagues at the University of Basel and the University of Applied Sciences Northwestern Switzerland (FHNW) through the PhD School and the Nano Argovia program. We appreciate this regular exchange of ideas with colleagues, which provides a steady stream of new ideas for projects and lines of research."

Professor Joël Mesot, outgoing Director of the PSI and a long-standing member of the SNI Argovia Board, is also full of praise: "It's been a pleasure for me to support the positive development of the SNI over the last ten years. The SNI has established itself as a center of excellence in research and teaching, and also provides an ideal platform for companies to access and benefit from nanoscience research."

Joël Mesot left the PSI at the end of 2018 to become President of ETH Zurich. On behalf of the whole SNI, we would like to express our sincere gratitude for his support over recent years and wish him all the best for the future.

Nano Study Program



97

In 2018, 52 students were enrolled on the bachelor's program and 45 on the master's program.

25%

25% of the students are women.

21+13

21 students successfully completed the bachelor's program and 13 completed the master's program.

36

In 2018, students were able to choose from 36 different block courses.

6

Six students received Argovia Travel Grants, which support students completing projects and master's theses abroad. The students worked at Harvard Medical School in Boston, Duke University, and Stanford University (all in the USA) as well as at Osaka Prefecture University (Japan), the International Iberian Nanotechnology Laboratory (Portugal), and the Technical University of Denmark.

8

As part of the study program, students visited the companies Sensirion, Mibelle, Nanosurf, Glas Trösch, CSEM, BASF, ABB, and Rolic Technologies.

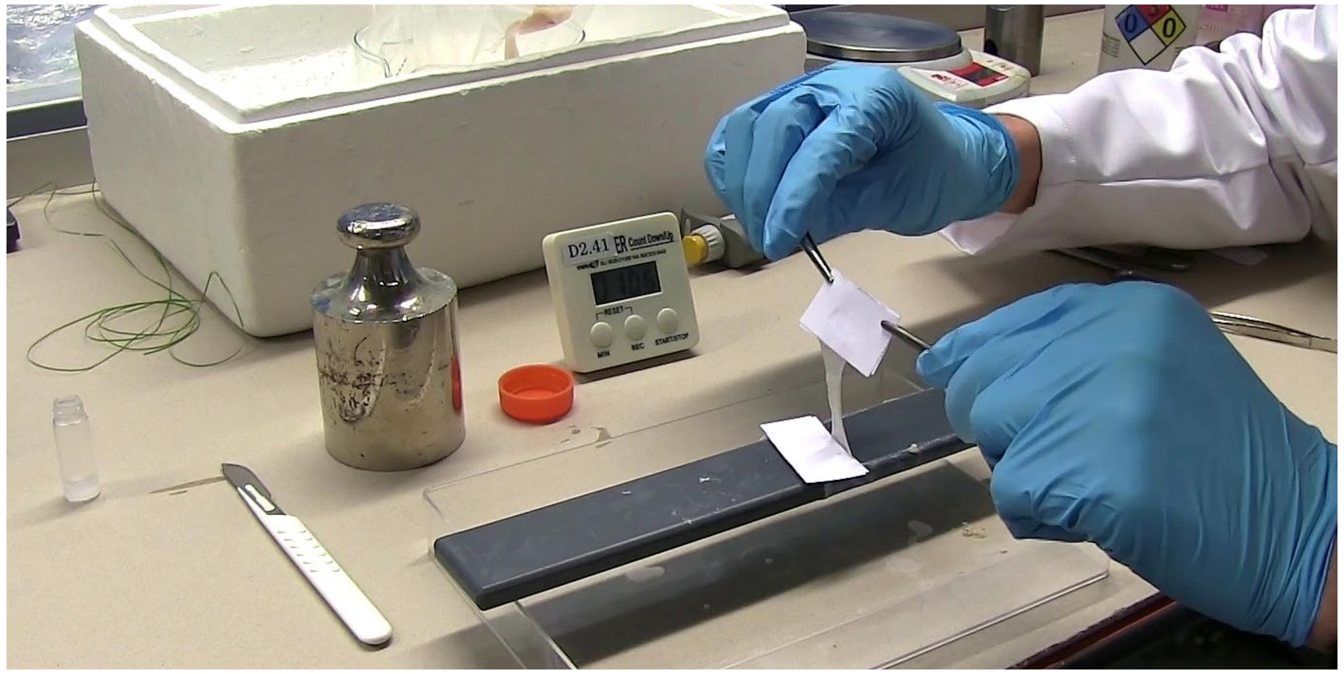
Iron oxide nanoparticles accumulated inside a zebrafish embryo
(Image: Emre Cörek, Department of Pharmceutical Sciences, University of Basel)

Glued wounds heal better

Tino Matter wins the prize for the best master's thesis

As part of his master's project at the Swiss Federal Laboratories for Materials Science and Technology (Empa), Tino Matter studied bioactive nanoparticles that ensure rapid wound closure and aid healing. In 2018, the project received the prize for the best master's thesis in nanosciences at the University of Basel.

Tino Matter would choose to study nanosciences in Basel again in a heartbeat.



For his master's thesis, Tino Matter worked on the development of a wound glue. (Image: Tino Matter)

"The first couple of years were very time-consuming, but the subject matter was exciting and it's incredible what I learned in that time."

Tino Matter, a former student on the nanosciences program at the University of Basel and now a PhD student at Empa

A promising approach
In his prizewinning master's project, Tino Matter investigated the viability of various nanoparticles as wound glues. With the help of a technique known as flame synthesis, he first prepared a range of nanoparticles and investigated their adhesive effect and ability to stop bleeding. He then combined the particles with other materials and tested additional properties, such as their antimicrobial activity, stimulant effect on blood vessel formation, and effectiveness as antioxidants.

"Nanoparticles in combination with bioactive glass (bioglass) turned out to be particularly promising candidates," he says. "Thanks to their large surface area, they adhere excellently to tissue and therefore act as a glue. They also have a significant stimulatory effect on clotting." In combination with tiny quantities of silver, the bioglass nanoparticles exhibit antimicrobial properties. If strontium is added as a dopant, new blood vessels develop more rapidly, aiding the wound-healing process. In all these approaches, testing the absolute safety of the various material combinations is critical for the research team working under Empa's Dr. Inge Herrmann, who supervised Tino during his master's thesis.

Tino Matter had already studied the topic of wound glues in one of the projects he completed during his nanosciences degree. Even now, after successfully completing his master's degree, he is still hooked on the topic. For his doctoral dissertation in Inge Herrmann's research group, he is also keen to work closely with surgeons to develop a method that improves wound healing for the benefit of future patients.

An ideal introduction
Tino Matter is glad that he came to Basel in 2012 to study nanosciences, and he would choose this demanding interdisciplinary degree program again in a heartbeat. "The first couple of years especially were very time-consuming, but the subject matter was exciting and it's incredible what I learned in that time," he recalls. Like so many of his colleagues, he particularly remembers the block courses. Here, students gain an insight into various fields and "learn about the mentality of the various disciplines," he says. At any rate, the nanosciences degree provided him with a perfect introduction to the exciting world of science, where many questions can only be answered by an interdisciplinary team.

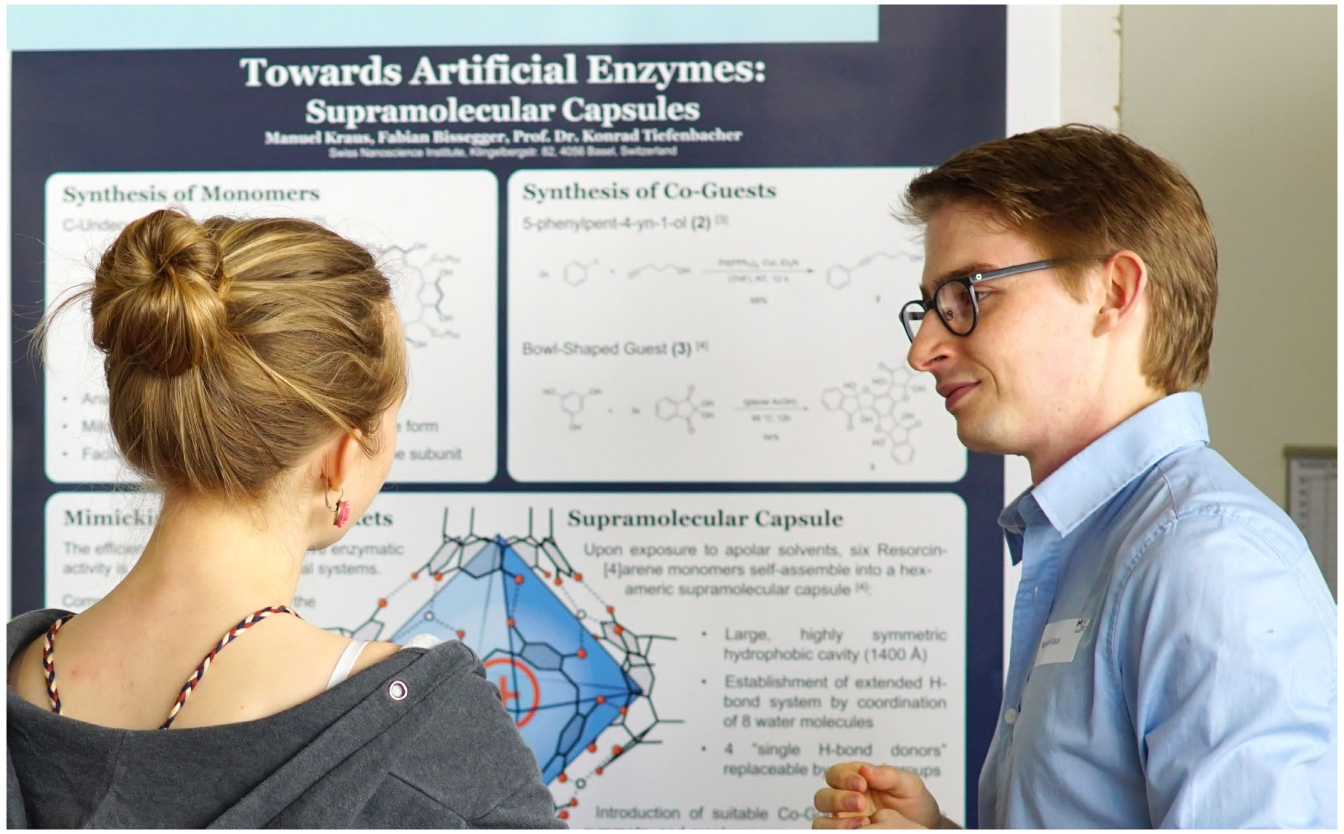
Discussing science at SmallTalk

Students organize their own symposium about the block courses

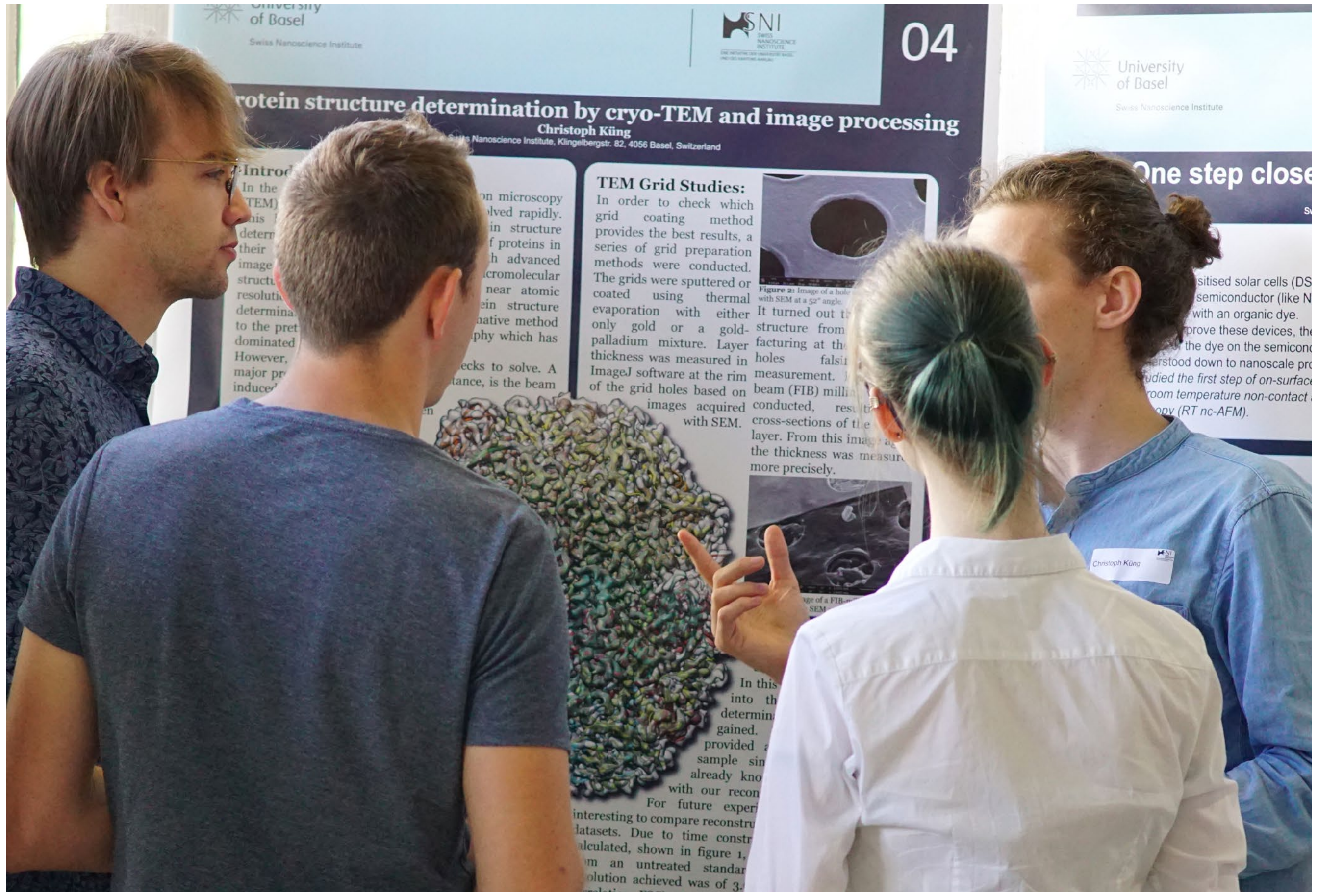
In the last two semesters of their bachelor's studies, nanoscience students each attend eight block courses, selecting those that interest them from a varied list of available subjects. What better way for them to report back to fellow students on their experiences in the various research groups within the SNI network than as part of a one-day symposium organized by the students themselves? The official format known as SmallTalk was recently introduced for this purpose and gives students an opportunity to hone their professional communication skills by presenting the lines of research they worked on in the block courses.

Selection based on students' interests
Corinne went to the Paul Scherrer Institute, the FHNW School of Life Sciences, the Nano Imaging Lab, the Department of Physics, and the Biozentrum. Manuel attended courses at the Adolphe Merkle Institute, the Department of Chemistry, and the Biozentrum, as well as at the FHNW Schools of Engineering and Life Sciences. Like all nanoscience students, they attended these block courses in the fifth and sixth semesters and could choose courses whose topics they found particularly interesting.

Insight into different areas of research
Students select eight courses, each lasting between one and three weeks, from a varied list of over 35 subjects. Provided by various partners in the SNI network, these courses not only give students an excellent insight into current nano research but are also a chance to get to know various research groups within the network. Time and time again, students tell us that the block courses are the highlight of the bachelor's program. For example, Manuel Kraus describes the experience by saying: "We gain an insight into cutting edge research and get to know the language used in the various disciplines."



During the SmallTalk conference, students discussed their experiences of the block courses.



The students presented their results in the form of posters and talks.

"This independently planned and executed conference is an excellent opportunity for young researchers to familiarize themselves with an additional aspect of scientific research and to practice giving professional presentations of their research findings."

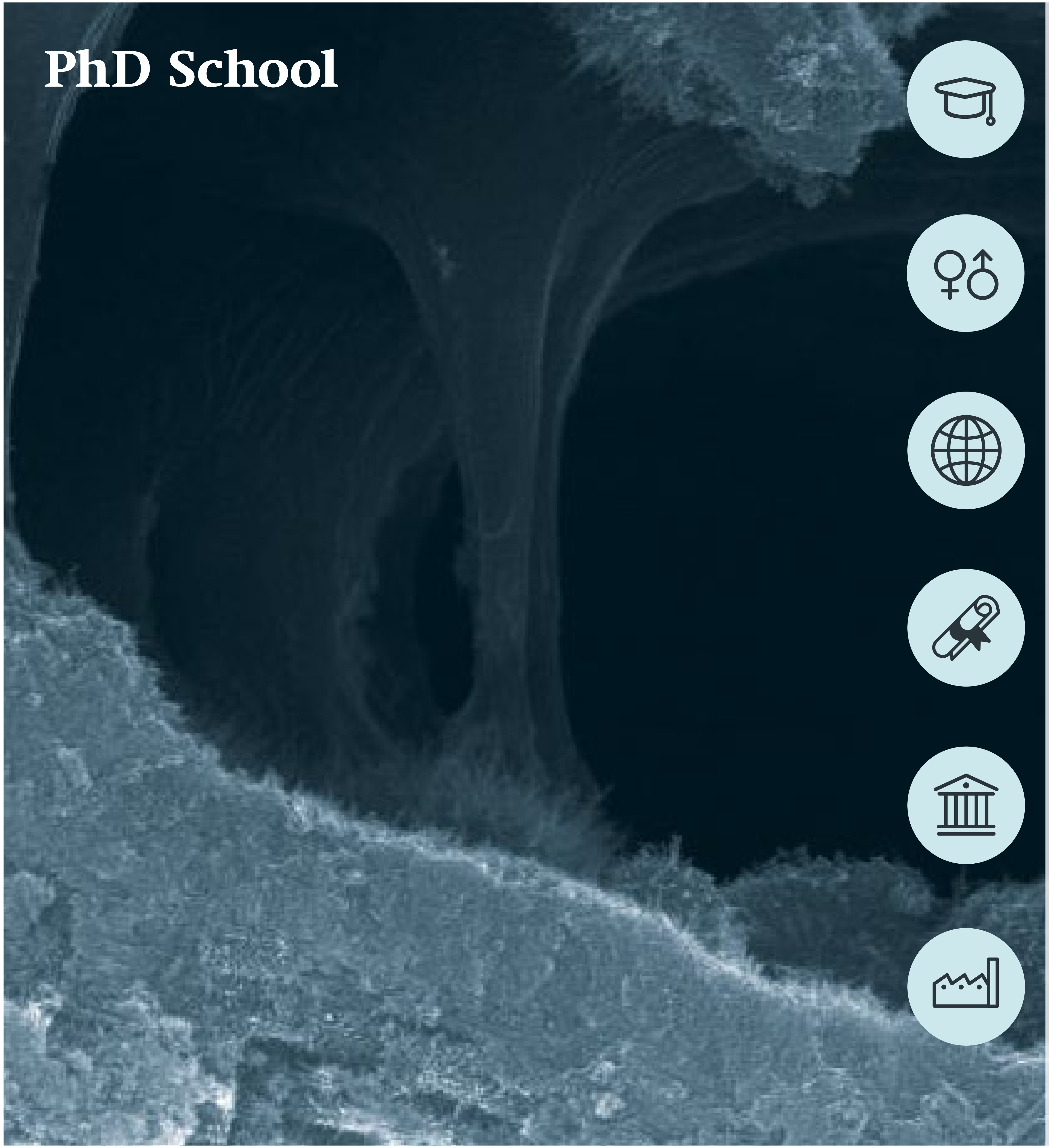
Dr. Anja Car, Coordinator of the nanosciences program at the University of Basel

Students' symposium
After completing the various block courses, nanoscience students organized their own symposium in May 2018 to discuss their results and experiences. Each student chose a topic and presented it in the form of a talk and a poster. Beforehand, the young researchers had attended a seminar where they learned how to design a good poster, what basic principles to adhere to in scientific writing, and how to capture the audience's attention in a talk.

Evaluators from the SNI network graded the presentations and noted that the students were already performing well in these areas. Professor Wolfgang Meier, leader of the degree program and one of the evaluators, said: "The students held this small symposium for the second time in 2018, and I was impressed with both the quality of the talks and the excellent organization." Fabian Oppliger, who received an award for his presentation about the nanolithography block course, gave a particularly impressive performance.

Dr. Anja Car, coordinator of the nanosciences program since 2018, also praised the introduction of SmallTalk: "This independently planned and executed conference is an excellent opportunity for young researchers to familiarize themselves with an additional aspect of scientific research and to practice giving professional presentations of their research findings."

PhD School



41

In 2018, 41 PhD students were enrolled in the SNI PhD School.

32%

32% of the PhD students are women.

16

PhD students from 16 different countries are enrolled in the SNI PhD School.

9

In 2018, nine doctoral students successfully completed their PhDs.

53%

53% of the 19 PhD students who had completed their PhDs by the end of 2018 work at a federal or research institution.

37%

37% of the 19 former PhD students work in industry.

Electron microscopy image of the hydrothermal synthesis of carbon nanotubes/manganese dioxide (CNT/MnO_2). (Image: Mehdi Ramezani, Department of Physics, University of Basel)

SNI PhD School
An excellent start of a scientific career

In 2018, nine young scientists successfully completed their PhDs at the SNI PhD School. They had carried out their practical work at the Department of Chemistry, Department of Physics, and Biozentrum of the University of Basel, at the School of Life Sciences of the University of Applied Sciences Northwestern Switzerland (FHNW), or at the Paul Scherrer Institute (PSI). During their four years at the SNI PhD School, the young scientists received an excellent scientific education and numerous opportunities for interdisciplinary exchange. They also benefited from courses developed specifically for the SNI PhD School on the topics of intellectual property, rhetoric, communication, and identifying personal strengths.

Minute molecular machines
Self-organization of functional supramolecular entities is an important process in biology. It relies on various interactions at the molecular level above and beyond covalent bonds.

For his doctoral dissertation, Dr. Yves Aeschi synthesized and characterized artificial mechanically interlocked systems in which a ring-shaped component encircles a straight axle. These connections, known as rotaxanes, are assembled by means of a hydrophobic driving force from suitable water-soluble precursors. Subsequent attachment of large terminal groups to the axle traps the ring on the axle, creating a mechanical bond. Introducing chemically or physically controllable subunits could then enable synthesis of minute molecular machines, which in turn could be used to form larger nanostructures.

After his PhD, Yves Aeschi took up a position at Dottikon ES.

“I had the opportunity to gain insights into interdisciplinary research at the boundary between chemistry, physics, and biology. The experience was both exciting and rewarding.”

Dr. Yves Aeschi, former PhD student at the SNI PhD School

Davide Cadeddu studied nanowires that can be used as sensors for electric fields.

Nanowires for sensor technology
In his doctoral dissertation in the group of Argovia Professor Martino Poggio, Dr. Davide Cadeddu studied nanowires with a view to using them as sensors. He successfully used special nanowires to construct a robust source of single photons directly coupled to an optical fiber that can be used in sensor technology. For this, he took a pointed nanowire with individual quantum dots on the tip and placed it in the middle of a glass fiber.

Without functionalization, the quantum dots emit single photons, while the wire guides the light into the fiber. Davide Cadeddu showed that these “quantum fiber pigtails” can produce a highly accurate and sensitive image of electric fields on the nanometer scale. In the process, the sample’s electric field causes changes in the energy state of the quantum dots and therefore in the color of the emitted light. Computer simulations provided Davide Cadeddu with the optimum geometry for the structure to improve the sensitivity.

Motor for molecular factories
As part of his doctoral dissertation, Dr. Roland Goers created an efficient motor for molecular factories by incorporating the proton pump proteorhodopsin into artificial polymer membranes.

This involves a self-assembly process that takes place when the components of the membrane are brought together with the proton pump protein in the right conditions. The pump can then create a concentration gradient of hydrogen ions (protons) between the interior of the tiny vesicle and its surroundings, and the resulting change in internal pH drives a chemical reaction or catalyzes an enzyme such as ATPase.

In order to achieve a uniform size and a maximum pumping capacity during self-assembly of the vesicle, Roland Goers developed a statistical model that provides an ideal basis for further optimizing and expanding the concept.

Roland Goers created an efficient motor for molecular factories.

“I discovered Switzerland thanks to the SNI. I had the opportunity to make new friends, forge numerous collaborations, and learn a lot of new things – not just about science. For all these fantastic and unforgettable memories, I’m deeply grateful to the SNI.”

Dr. Mina Moradi, former PhD student at the SNI PhD School

Ultrathin organic networks
Dr. Mina Moradi's doctoral dissertation centered around the fabrication of two-dimensional organic networks, which are associated with a large number of potential applications. She achieved this using building blocks known as calixarenes, a class of cup-like macrocyclic organic compounds (*calix* is Latin for "cup").

Mina Moradi designed the structure of these organic building blocks so that they would self-arrange into two-dimensional networks at an air/water interface without forming covalent or ionic bonds. Instead, dipole–dipole interactions stabilize the ultrathin film of crystalline building blocks, which is just a single layer of molecules thick. This film can be deposited to solid surfaces without altering the structure.

Since January 2019, Mina Moradi has been working as postdoc at EPFL.

Nanomembranes for structural analysis
In her doctoral dissertation, Dr. Nadia Opara developed and tested ultrathin membranes that can be applied as substrates for biological materials in structural studies.

By growing or placing protein crystals as well as individual biomolecules onto these thin films, she was able to analyze them using various diffraction-based techniques (synchrotron, X-ray free electron laser or electron microscope-based methods).

Additional placement of specially designed metallic markers onto the membranes makes it easier to localize the sample for serial data collection. Finally, regarding selection of the ideal substrate, Nadia also found that the key factors in that matter include the robustness of the material, optimum transparency to the applied radiation, and good compatibility with the sample material.

Nadia Opara would like to stay in research.

Traps for ultracold ions and neutral particles
As part of his doctoral dissertation, Dr. Ian Rouse developed a miniaturized trap for charged and uncharged particles.

This can be used to trap ions along with neutral atoms, which can then be analyzed at temperatures close to absolute zero (-273.15°C). If ions and neutral particles are trapped together, the measured energy distribution of the trapped ions deviates from that expected from thermodynamics.

In his dissertation, Ian Rouse investigated the underlying effects using both numerical and analytical methods, laying the foundation for the correct interpretation of experimental studies.

Ian Rouse worked with ultracold charged and uncharged particles.

"One of the highlights of the SNI PhD school was the focus on building a community of nanoscientists – rather than leaving everyone to work separately, we were given plenty of opportunities for exchange. This helped me settling in to a new country, and later on made sure I was getting an overview of activities outside my group."

Dr. Ian Rouse, former PhD student at the SNI PhD School

Video of nuclear pore complexes
For his doctoral dissertation in the group of Argovia Professor Roderick Lim, Dr. Yusuke Sakiyama studied a natural nanomachine and observed its operation in real time. He was the first person to successfully record movies of nuclear pore complexes in action. These nuclear pore complexes regulate the selective transport of larger molecules into and out of the cell nucleus and are a fundamental part of cell function.

Using a high-speed atomic force microscope, Yusuke Sakiyama was able to make live observations of molecular transport through the pores in the nuclear envelope of frog oocytes. The videos of these tiny nuclear pores, which have a diameter of just 40 nanometers even in the relatively large frog membranes studied here, confirmed their hypothesis of a dynamic system. Indeed, the tentacle-like proteins responsible for transport altered their arrangement constantly, and it is likely that the speed of their movements determines which molecules can pass through the pore.

Yusuke Sakiyama has started a postdoc position at EPFL.

Attachment of bacteria to surfaces
In her doctoral dissertation, Dr. Nora Sauter studied the forces and dynamics of external, threadlike appendages of *Caulobacter crescentus*. This bacterium is used as a model organism for biofilm-forming bacteria, which are of vital importance in medicine due to their resistance to antibiotics. The external appendages, such as flagella and fine hairs (pili), play a key role in motility and the bacterium's attachment to a surface. This is the first step in the formation of biofilms.

Performing the experiments in a microfluidic system with a liquid culture medium, Nora Sauter combined optical tweezers for contactless fixation of bacteria with a high-resolution optical microscope. This allowed her to observe precisely how sessile mother cells divide and mobile daughter cells are formed. She tracked the exact movements of flagella and pili, studied their role in cell division, and determined the forces with which the cellular appendages bind to surfaces.

Nora Sauter deepened her knowledge in two areas of research.

“Being actively involved in two research teams allowed me to deepen my knowledge in both areas of research.”

Dr. Nora Sauter, former PhD student at the SNI PhD School

Dilek Yildiz appreciated the interdisciplinary exchange at the SNI PhD School.

Energy conversion dependent on system

In her doctoral dissertation at the University of Basel’s Department of Physics, Dr. Dilek Yildiz used an atomic force microscope in pendulum mode to study energy conversion (dissipation) due to friction in two different systems.

Her results showed that the type of energy conversion in charge density waves depends on the ambient temperature and that, at low temperatures, energy is released primarily in the form of electrical dissipation (Joule heat). In topological insulators, on the other hand, the heat loss becomes vanishingly small. Insulators of this kind have a two-dimensional conductive surface, while the body itself has insulating properties.

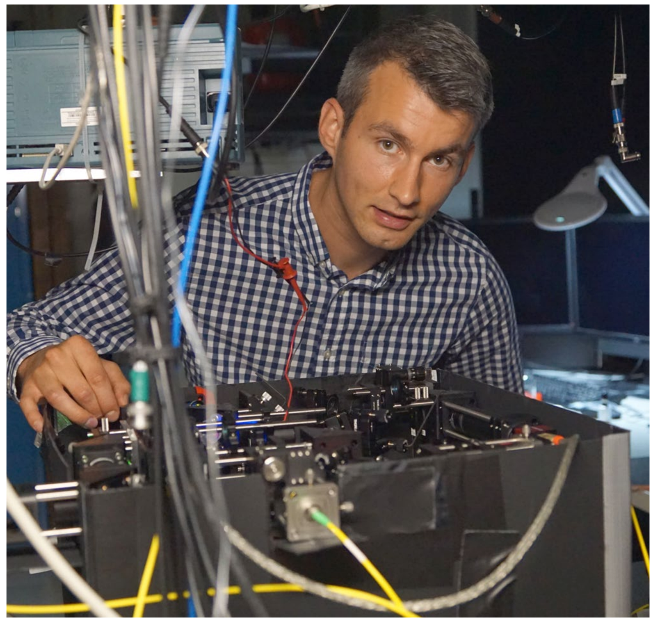
In her studies of the topological material bismuth telluride, Dilek Yildiz identified the formation of localized “image charge states”, which are responsible for a new type of dissipation mechanism based on quantum mechanics.

“I’ve benefited a great deal from the SNI PhD program and the interdisciplinary platform it created, allowing me to learn about key developments in other fields. Thanks to the SNI PhD program, I’ve attended numerous international conferences, which gave me the opportunity to present my work and build up my own network of scientific contacts.”

Dr. Dilek Yildiz, former PhD student at the SNI PhD School

Multiple awards
Daniel Riedel wins several prizes

In 2018, former SNI PhD student Dr. Daniel Riedel won several prizes for his doctoral thesis and an ensuing publication. As part of his dissertation at the SNI PhD School, he drastically improved the quality of individual photons generated by a quantum system, successfully putting a ten-year-old theoretical calculation into practice.



For Daniel Riedel, his doctoral dissertation felt like a hobby.

Daniel Riedel’s doctoral dissertation was supervised by Professors Richard Warburton and Patrick Maletinsky from the University of Basel’s Department of Physics and centered around particles of light (photons) emitted by nitrogen-vacancy centers (NV centers) in diamonds. These photons are to be used to read the quantum state of the NV centers. However, the detection rate of these photons is very low due to the large difference in refractive index between diamond and air, which causes most of the light emitted by the NV centers to be reflected inward at the interface and thus to remain trapped in the diamond.

Greater light yield

Riedel’s aim was to boost the photon yield of the NV centers without impairing their other positive properties in the process of nanofabrication. He began by considering the entire spectral region of the emitted light. Using a dielectric optical antenna based on a diamond membrane, he was able to concentrate the photons in a specific direction and thus to capture them using a conventional lens. “I studied the antenna’s radiation pattern for various layer thicknesses of the diamond membrane and found that it agreed excellently with an analytical model I had developed. For very thin diamond layers, I was able to improve the light yield of individual NV centers by an order of magnitude,” Riedel explains.

Improved quality

Information transfer in technological applications of NV centers relies on their quantum mechanical entanglement using photons. However, this can only be achieved with the help of coherent photons, which make up just three percent of the total emission. In a publication in “Physical Review X”, Riedel described how he had succeeded in raising the proportion of coherent NV photons by more than an order of magnitude, from three to almost 50 percent. For this, he incorporated a diamond membrane into an optical microresonator and thereby boosted the emission rate within a narrow frequency range – in line with theoretical predictions made ten years beforehand.

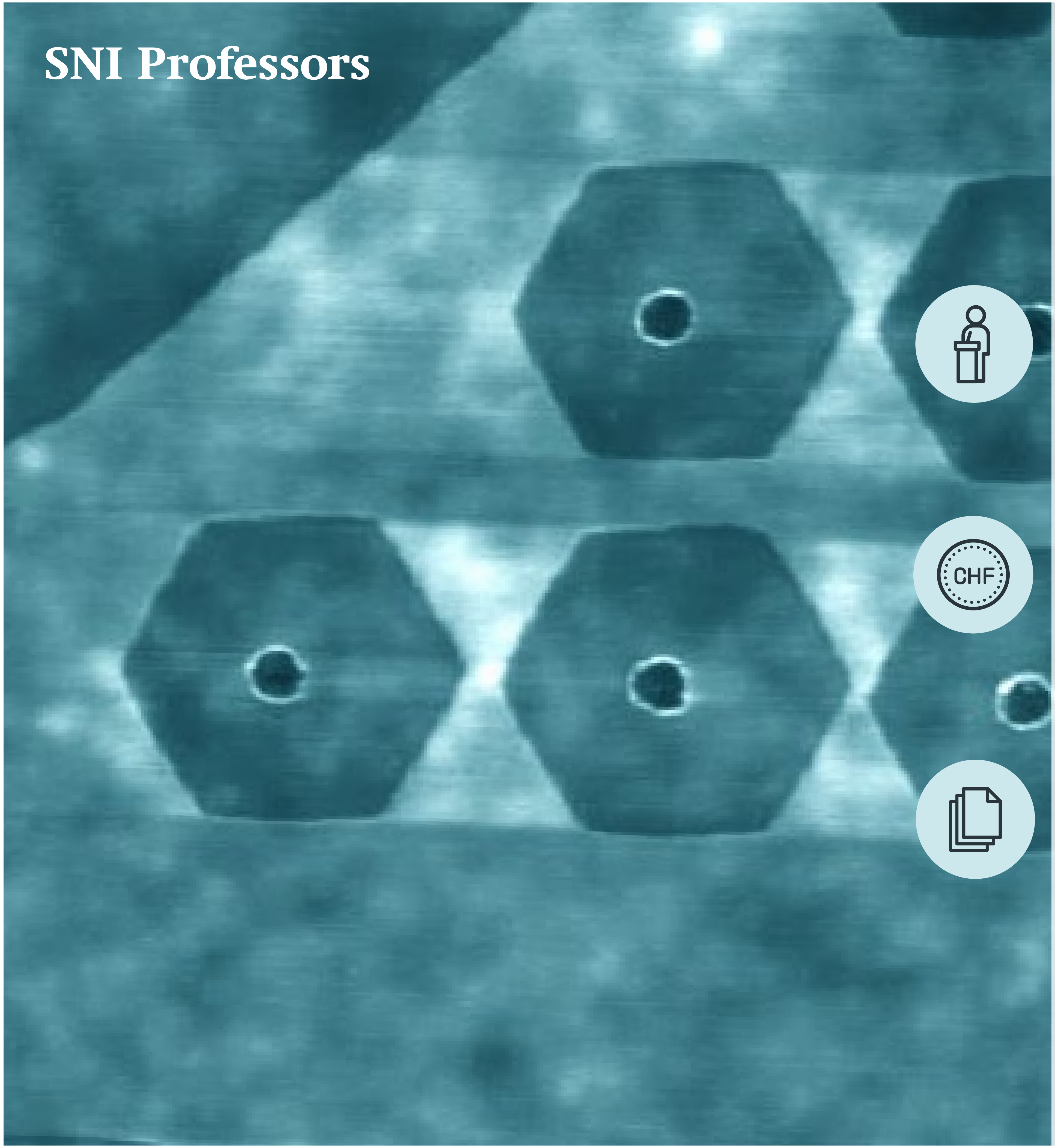
A successful year

For this publication, Riedel was presented with the Swiss Micro & Nanotechnology Network’s PhD Award, which is sponsored by the Hightech Zentrum Aargau, at the Swiss Nano Convention in June 2018. His overall doctoral dissertation earned him second place in the “dissertations” category of the Quantum Future Award from the Federal Ministry of Education and Research in Germany (BMBF) and the Center for Integrated Quantum Science and Technology (IQST). In his home town of Dinkelsbühl, Germany, he was also awarded the 2018 sponsorship prize from the Willi Dauberschmidt Foundation. The Postdoc.Mobility Fellowship from the Swiss National Science Foundation (SNSF) will enable Riedel to embark on the next step of his career as a postdoc at the California Institute of Technology in Pasadena, USA.

“The events organized by the SNI taught me to look beyond the boundaries of my own research.”

Dr. Daniel Riedel, former PhD student at the SNI PhD School

SNI Professors



5

The SNI financially supports five professors. Argovia professor Martino Poggio works at the Department of Physics, Argovia professor Roderick Lim at the Biozentrum at the University of Basel. Thomas Jung, Michel Kenzelmann, and Frithjof Nolting are titular professors, who teach at the University of Basel and lead research teams at the Paul Scherrer Institute.

1.9 Mio.

In 2018, the Argovia professors Martino Poggio and Roderick Lim managed to attract about 1.9 million Swiss Francs in external funding for their research.

11

The Argovia professors and their teams published 11 scientific papers, one contribution to a book, and gave 20 talks at various national and international conferences.

AFM picture of single layer graphene on top of an hBN substrate after hydrogen plasma etching which created the hexagonal holes. (Image: Mirko Rehmann, Department of Physics, University of Basel)

Martino Poggio studies nanowires

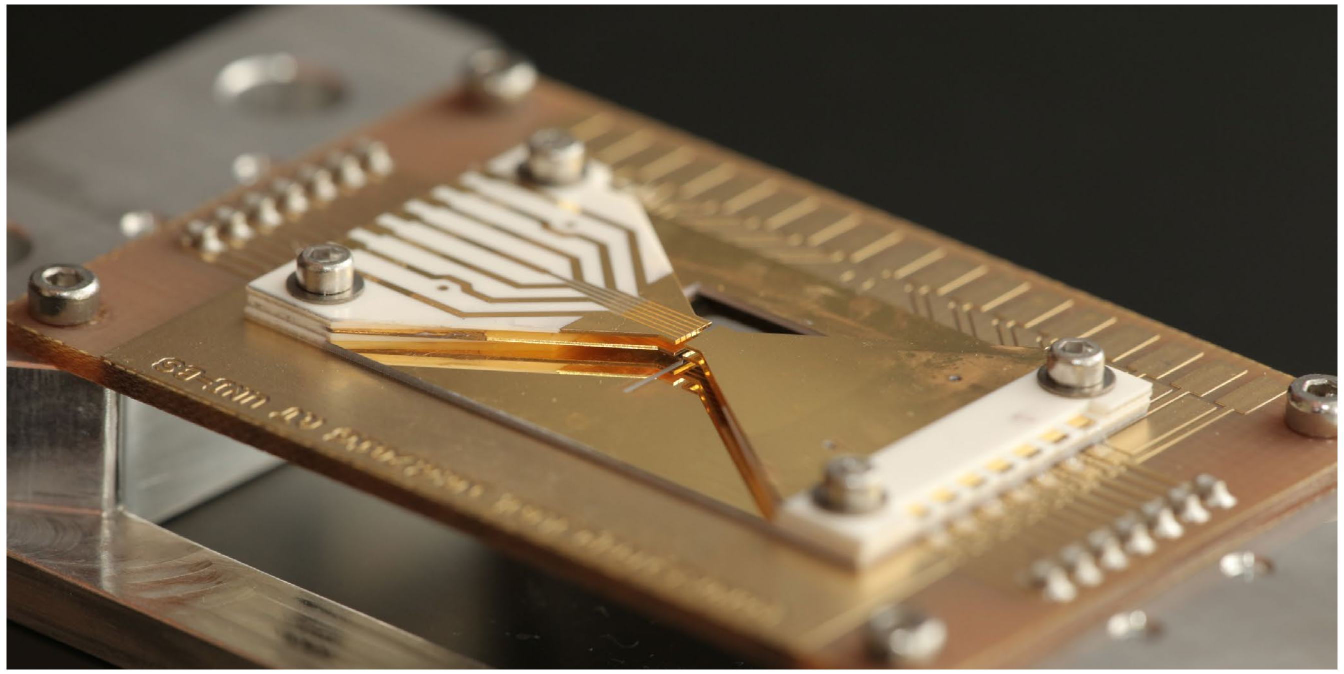
These tiny wires with special properties have a variety of potential applications

Argovia Professor Martino Poggio, from the Department of Physics at the University of Basel, leads a team studying nanowires that are suitable for a wide range of applications. In 2018, the group published findings relating to ferromagnetic nanowires that could be used to store data. A collaboration with Professor Stefan Willitsch also led to the first publication about an innovative line of research in which ultracold ions are coupled with nanowires. In a further highlight, the Poggio team organized a workshop as part of a Switzerland-wide research network that studies so-called “skyrmions”.

“The SNI is the ideal plattform for interdisciplinary research projects.”

Argovia-Professor Martino Poggio, Department of Physics, University of Basel

Simon Philipp and Martino Poggio work on so-called “skyrmions” and are engaged in a Sinergia projekt.



This set-up is used to couple ultracold ions with a nanowire. (Image: Panagiotis Fountas)

Ferromagnetic nanowires as data storage

For many years, Martino Poggio’s research has focused on the potential applications of nanowires. These long, thin crystals with almost defect-free crystal lattices have an enormous surface area relative to their volume, as well as a very low mass, making them ideal for use as sensitive sensors of electric and magnetic fields. Poggio’s group also studies ferromagnetic nanowires, which are mooted as a potential data storage medium of the future. In a 2018 publication in “Physical Review B”, the team was able to show how magnetization behaves in the outer surfaces, corners and edges of a nanowire and how it can be reversed. The latter is a basic prerequisite for applying these magnetic structures to data storage.

Magnetic vortexes for storing data

In the future, new types of data storage could also be created using “skyrmions” – magnetic vortexes that exhibit particle-like behavior. As well as being highly resistant to external influences, skyrmions are very small and can be modified by electric fields – all factors that make them good candidates for applications in compact data storage. With a view to identifying and manufacturing new types of skyrmion-containing materials that are suitable for technical applications, a Sinergia project has been supported by the Swiss National Science Foundation (SNSF) since 2017. Martino Poggio is one of four project leaders in this Swiss research network, which was launched by Professor Dirk Grundler (EPF Lausanne).

In November 2018, participating doctoral students and scientists from the University of Basel, the Paul Scherrer Institute (PSI), and EPF Lausanne attended a workshop in Basel that was initiated and organized by Simon Philipp, a doctoral student working at the Poggio lab. “Everyone involved felt it was a successful event that brought the network closer together. In addition, the two talks by the leading experts on the subject of nanoscale imaging of magnetic materials, Professor Hans Hug (Empa) and Professor Dieter Kölle (University of Tübingen), provided all of us with some valuable insights,” says Martino Poggio.

Coupling with ultracold ions

Since 2015, Martino Poggio and Stefan Willitsch, from the Department of Chemistry at the University of Basel, have been jointly supervising a doctoral dissertation at the SNI PhD School on the coupling of nanowires with individual ultracold ions. The two scientists launched this interdisciplinary project both in order to control individual ultracold ions via a nanowire and also to enable the reverse: influencing a nanowire via an ultracold ion. In 2018, Panagiotis Fountas – the doctoral student carrying out the work – co-authored an initial paper with Martino Poggio and Stefan Willitsch describing simulations of the planned experiments. These simulations showed that it is theoretically possible to couple the tiny ion with relatively large nanowires.

The scientists want to use their forthcoming experiments to combine two quantum mechanical systems and thereby to create a new hybrid system that offers new insights into the boundary between quantum mechanics and classical physics. Martino Poggio finds one aspect of the study particularly fascinating: “Theoretically, the current simulations show that an ultracold ion could be used to place a mechanical nanowire with a length of a few hundred nanometers into a quantum mechanical state and to study decoherence effects.”

Roderick Lim researches the transport processes and mechanical properties of cells

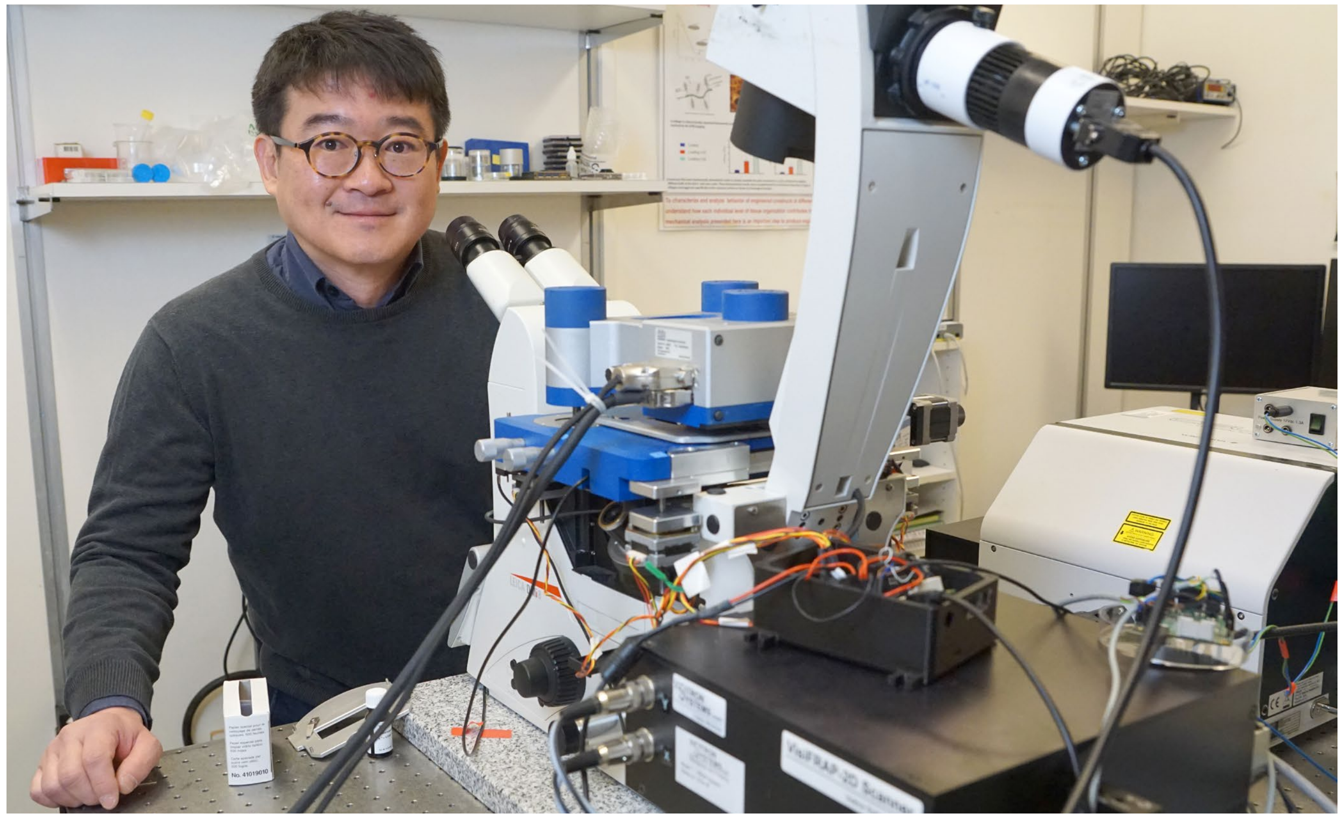
Promising applications form a key part of his research

Argovia Professor Roderick Lim from the Biozentrum at the University of Basel leads a team studying the molecular mechanics and selective transport processes of living cells. Lim believes it is important not only to understand the biological processes but also to keep an eye on potential applications of his findings. Currently, a start-up from his laboratory – ARTIDIS AG – runs its first clinical trial. In addition, Roderick Lim works alongside colleagues to supervise SNI doctoral dissertations whose findings make a key contribution to potential future applications.

Interested in the strength of cells

For many years, Roderick Lim and his team have been using atomic force microscopy to investigate the stiffness of cells in tissues. Their work has revealed that malignant cancer cells differ from healthy cells in terms of their mechanical properties. Realizing that this can be transformed into a rapid, reliable and cost-effective method to diagnose cancer, at the same time as optimizing treatments, Lim together with colleagues Dr. Marija Plodinec and Dr. med. Marko Loparic founded the start-up ARTIDIS AG in 2014.

Based at Technologiepark Basel, Marija Plodinec has led ARTIDIS from strength to strength as the Chief Executive Officer. A key milestone was the launch of its first clinical trial in 2016, which will be closed in 2019 and has been carried out in collaboration with Roderick Lim and Dr. med. Rosemarie Burian at the University Hospital Basel. In this study, the ARITIDIS platform measures over 500 female patient biopsies and its results are compared to clinical, histological and genetic analyses, thereby delivering personalized nanomechanical biomarker results of each patient.



It is important for Roderick Lim to keep an eye on potential applications of his scientific findings.

"This is exemplary of how a private-public partnership can benefit society," explains Lim. "ARTIDIS delivers a diagnosis within just three hours. In addition to that, the quantitative data enables us to predict whether the tumor will form metastases, hence we can optimize treatment accordingly and improve patient outcomes," adds Plodinec.

Vesicles as specific transport containers

A more recent breakthrough that has emerged from the Lim lab in close collaboration with the group of Professor Cornelia Palivan from the Department of Chemistry promises to improve applications in gene therapy. This involves a team effort from both groups, including SNI doctoral student Christina Zelmer who is studying artificial vesicles (polymersomes) that could deliver drug molecules into specific organelles on a highly selective basis.

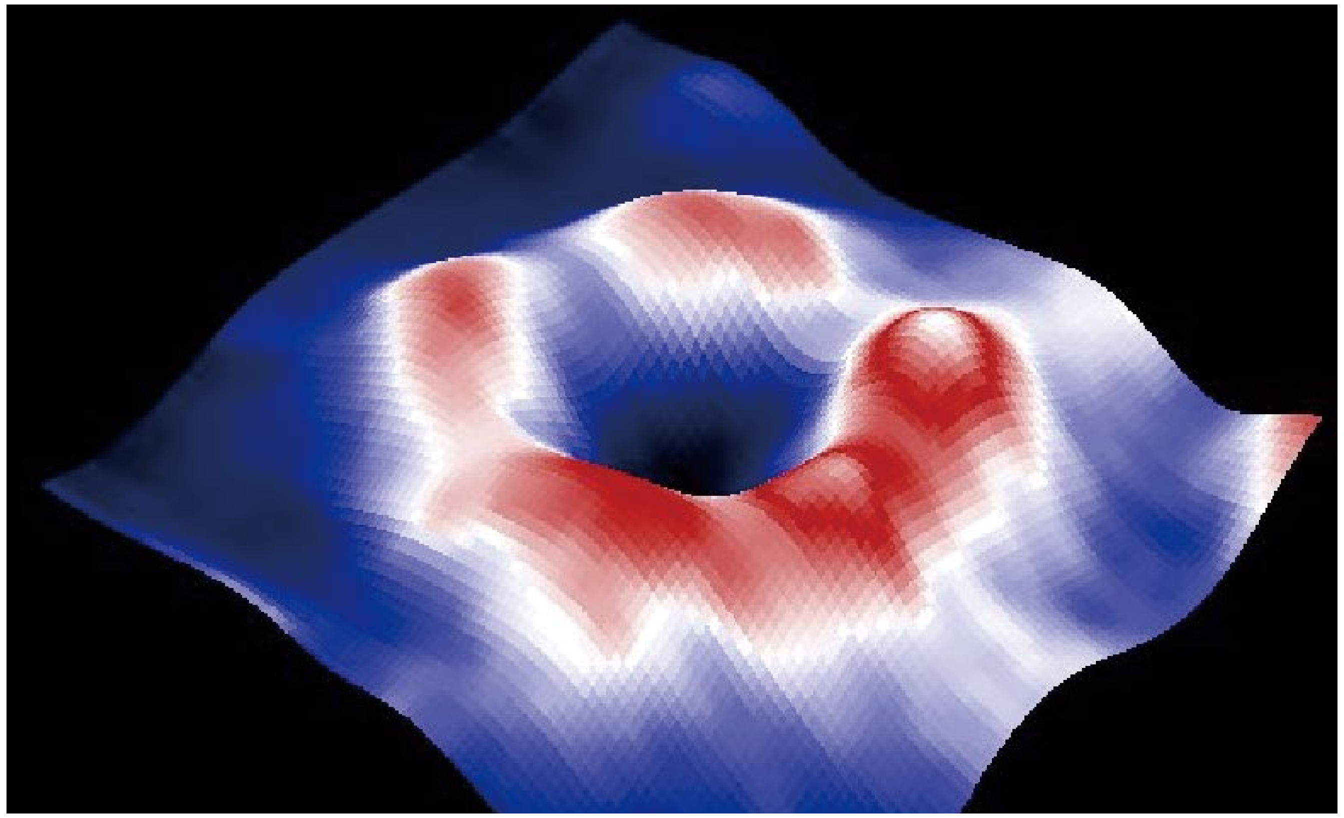
Importantly, Zelmer and colleagues recently managed to create polymersomes that "hijack" the cells internal transport system to enter into the nuclei of living cells, which remain viable even after the polymersomes are "smuggled" in. "This project represents a perfect synergy between both the Lim and Palivan labs. Our success is only possible thanks to our combined understanding of the chemistry of biofunctional polymers, cell biology, and how nuclear pore complexes work," says Roderick Lim in praise of the collaboration.

Artificial nuclear pores

For over a decade, Lim's team has made pivotal contributions to the understanding of nuclear pore complex function. Briefly, these pores are large molecular machines that selectively control transport into and out of the cell nucleus. In 2018, the scientists of the Lim team investigated two key nuclear pore proteins that anchor the rest of the pore complex components to the nuclear envelope.

Using a high-speed atomic force microscope, SNI doctoral student Toshiya Kozai succeeded in visualizing these two proteins and found that they formed nanopores in phospholipid membranes. In the course of his project, which is led by Lim and co-supervised by Professor Ernst Meyer from the Department of Physics, he will attempt to mimic a natural nuclear pore as closely as possible – from the bottom-up – by linking other pore proteins to the established structure.

"In doing so, we will not only expand our understanding of how nuclear pores work, but also converge on some interesting "out-of-the-box" applications in nano- and bio-technology", says Lim.



Two proteins that anchor the rest of the pore complex components to the nuclear envelope are enough to form a nanopore in a phospholipid membrane. (Image: Toshiya Kozai)

The SNI supports PSI titular professors
Thomas Jung studies nanonetworks

Professor Thomas Jung leads a research group at the Paul Scherrer Institute (PSI) as well as a team at the University of Basel's Department of Physics. His groups study molecules and nanostructures on surfaces with a view to potential applications in a wide range of areas. Jung is interested in the mechanical, magnetic and electronic properties of the molecular surface structures, which self-assemble in suitable conditions but can also be formed by specific on-surface chemical reactions or by the precise placement of individual atoms or molecules.

Physics and chemistry of pores

His investigations focus on two-dimensional networks of identical building blocks, as well as metal-organic frameworks (MOFs). These compounds made up of metals and organic building blocks form a regular arrangement of pores, which are studied in relation to molecular data storage devices, for example, as well as in catalysis and electrochemistry.

Until 2018, Thomas Jung was the supervisor of a doctoral dissertation at the SNI PhD School, working closely alongside Professors Catherine Housecroft and Edwin Constable from the Department of Chemistry. In the dissertation, Dr. Thomas Nijs demonstrated how much the architecture of MOFs can vary in response to changes in the initial building blocks and in the conditions for self-organization. For example, the scientists used detailed images obtained using a scanning tunneling microscope to show that, in certain conditions, ladder-like structures can be converted into rhombuses simply by increasing the temperature.

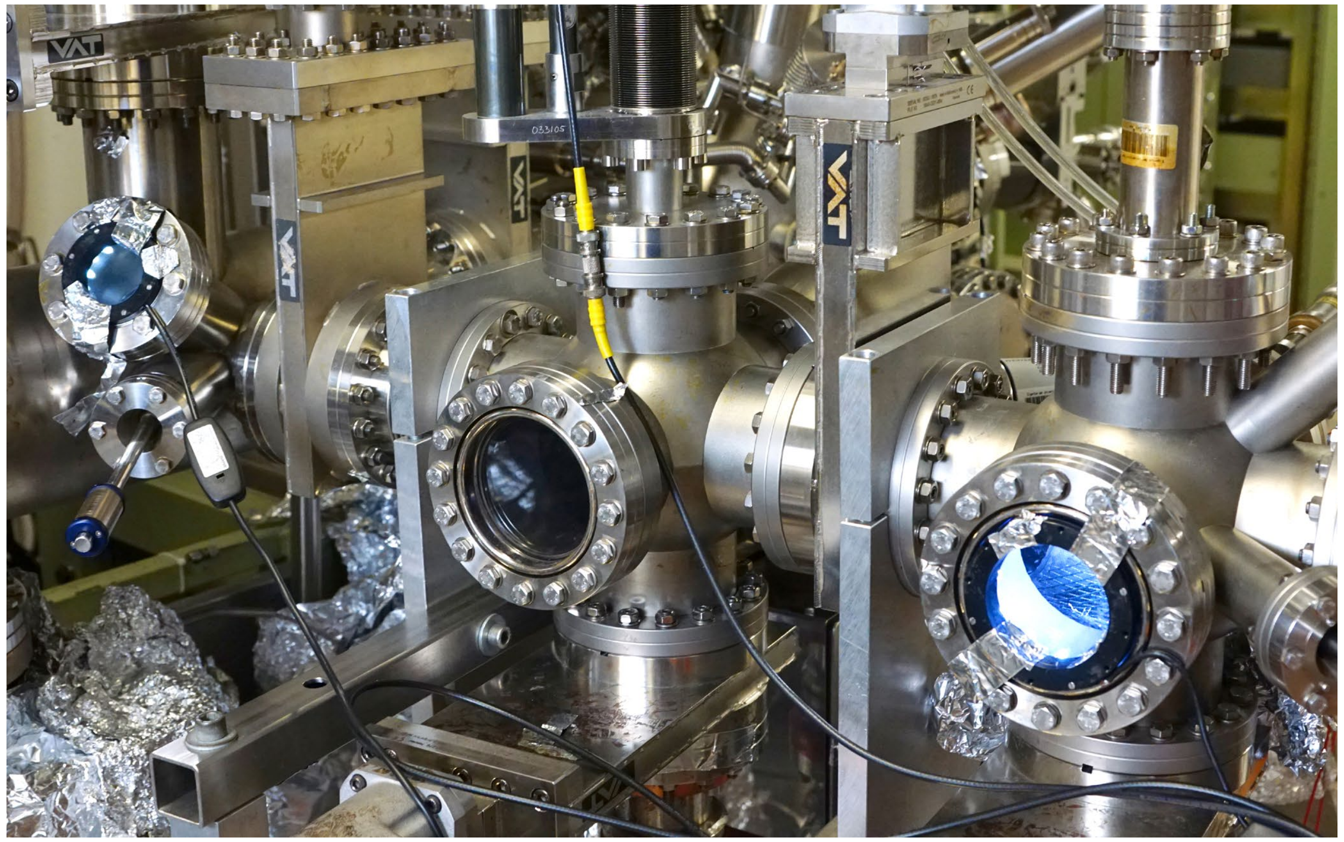
Aisha Ahsan and Thomas Jung are able to control single gas atoms in metal-organic frameworks.

Basis for data storage units

Metal-organic frameworks of this kind could also form the basis for tiny storage units made up of just a few atoms, as demonstrated in another doctoral dissertation supervised by Thomas Jung. In her dissertation, Dr. Aisha Ahsan began by producing a self-organized organometallic network that resembled a sieve with precisely defined pores. She then introduced xenon gas atoms into the pores, which were just over a nanometer in width. Using temperature changes and by applying localized electrical pulses, Aisha Ahsan was able to switch the state of the xenon atoms back and forth between solid and liquid. In principle, a phase change of this kind at the level of individual atoms could be used to store data, opening up entirely new possibilities for the development of tiny data storage devices, as Jung's team described in a 2018 publication in the journal "small".

"The work of my groups at the University of Basel and the PSI excellently complement each other. We can use the infrastructure at both sites and benefit from the scientific exchange with our colleagues."

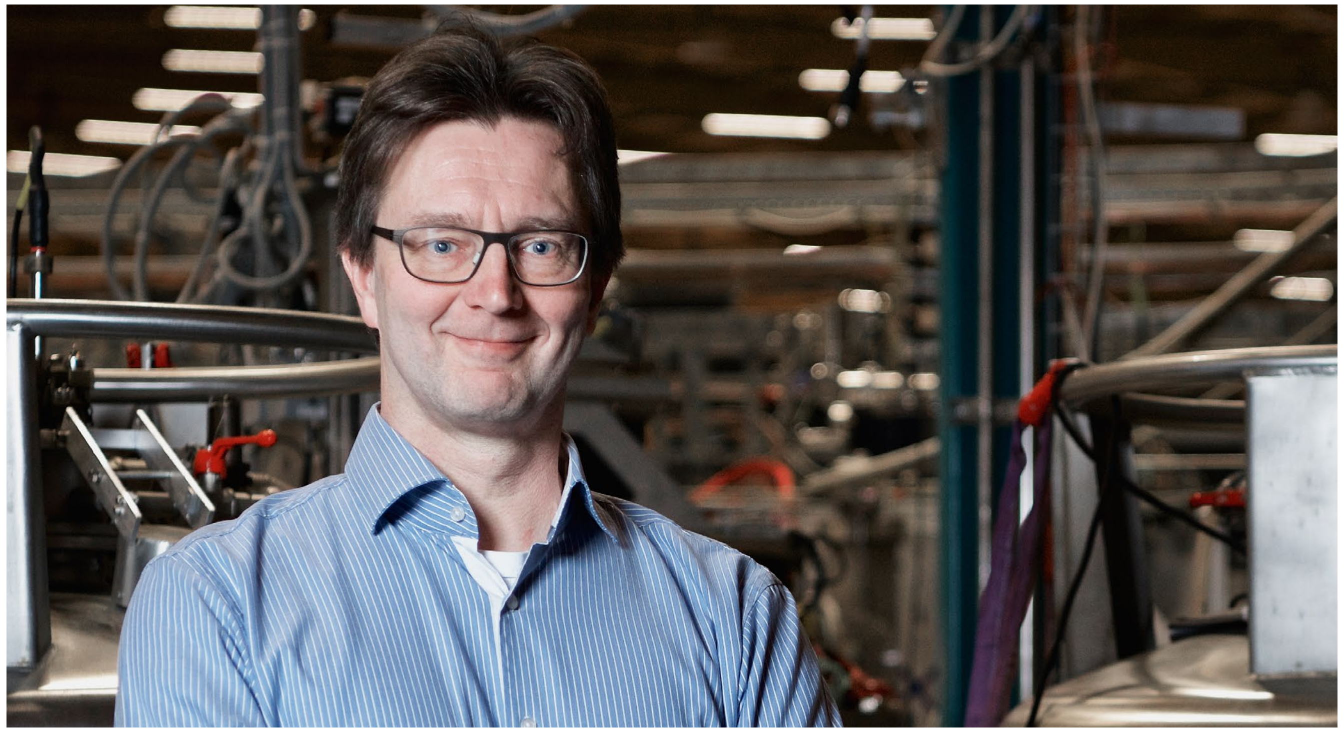
Prof. Thomas Jung, Department of Physics, University of Basel and Paul Scherrer Institute



Single molecules can be placed on surfaces in an ultra-high vacuum system.

Frithjof Nolting is a specialist in analyses using the Swiss Light Source

Professor Frithjof Nolting is head of the Laboratory for Condensed Matter in the area of photon research at the Paul Scherrer Institute and a titular professor at the University of Basel's Department of Physics. Driven by a fascination for the magnetic properties of tiny nanosystems, he and his team study one- to three-dimensional systems using a range of instruments. Chief among these is the Swiss Light Source (SLS), whose light is emitted by electrons moving on a circular path at nearly the speed of light. The wavelength of the light can be adjusted precisely between those of UV and X-rays, allowing analysis of a wide range of materials.



Frithjof Nolting leads the Laboratory for Condensed Matter in the area of photon research at the PSI and teaches as a titular professor at the University of Basel's Department of Physics. (Image: Paul Scherrer Institute)

Electronic and magnetic interactions

His own research work focuses on electronic and magnetic interactions on the nanometer scale: What happens at the boundary layer between two materials? How do magnetic properties come about and how can they be modified and optimized in a targeted manner? Can lasers or electric fields be used to alter magnetization? These are all key questions when it comes to developing the scientific basis for new data storage technologies, for example.

Crystal defects have a major influence

Highlights in 2018 included an analysis of the correlation between magnetic and atomic structure in nanoparticles, with the surprising result that so-called crystal defects (deviations from the perfect crystal structure) have a greater influence on magnetic behavior than previously thought.

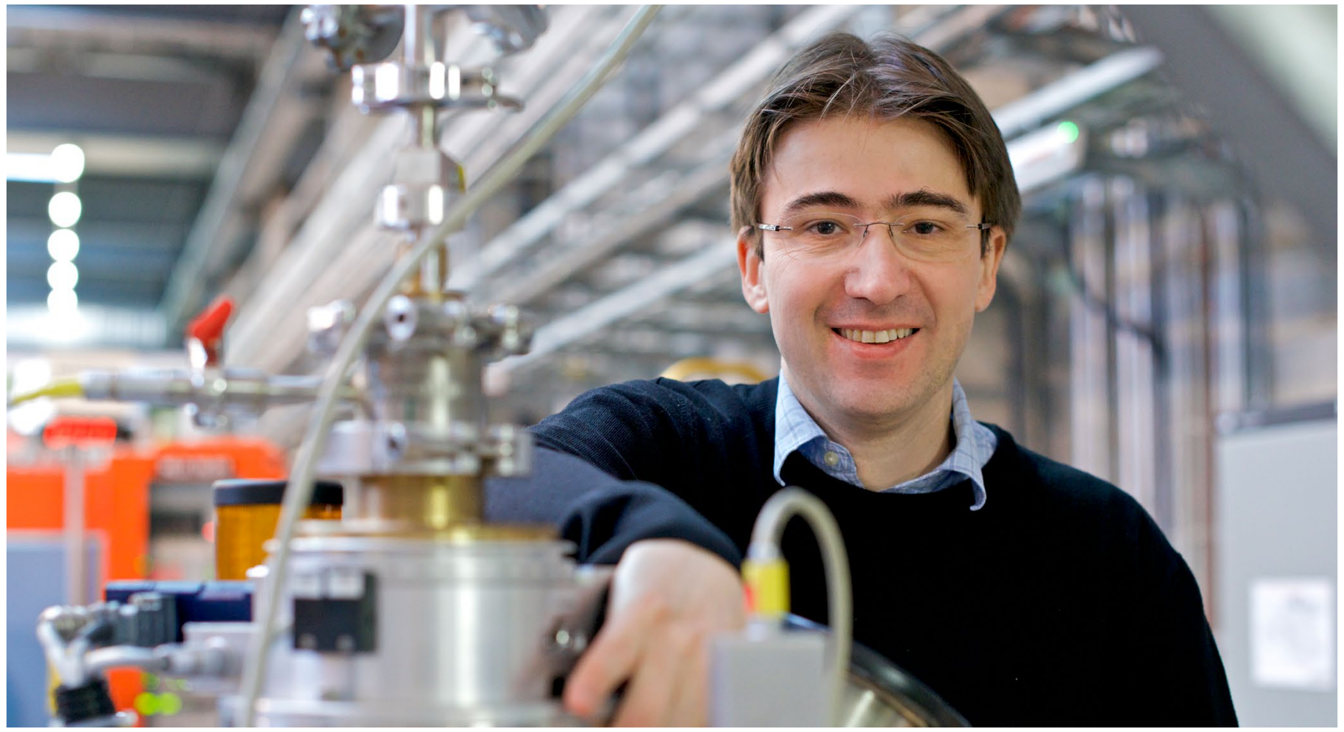
A wide range of topics

In addition to Nolting's own research, in the Laboratory for Condensed Matter are also six different research groups that study a wide range of topics. These range from materials for new manufacturing technologies to topological materials and ultra-fast processes in solids. In addition, these groups develop and operate experimental stations at the SLS and at SwissFEL, the X-ray laser at the Paul Scherrer Institute, and make these stations available for use by other research groups.

One key highlight in 2018 was the successful commissioning of the "Bernina" experimental station at SwissFEL. This allows researchers to study ultra-fast processes in solids and thus to gain important insights into the origin of magnetic properties.

Michel Kenzelmann researches materials with unusual magnetic properties

Professor Michel Kenzelmann leads the Laboratory for Neutron Scattering and Imaging at the Paul Scherrer Institute and teaches as a titular professor at the University of Basel's Department of Physics. He analyses materials whose magnetic properties differ significantly from those of the bar magnets we know from school. For example, he studies a material known as quantum spin ice, which may be suitable for use in future quantum computers, among other applications.



Michel Kenzelmann leads the Laboratory for Neutron Scattering and Imaging at the PSI and teaches as a titular professor at the University of Basel's Department of Physics. (Image: Paul Scherrer Institute)

Spin ice is of particular interest

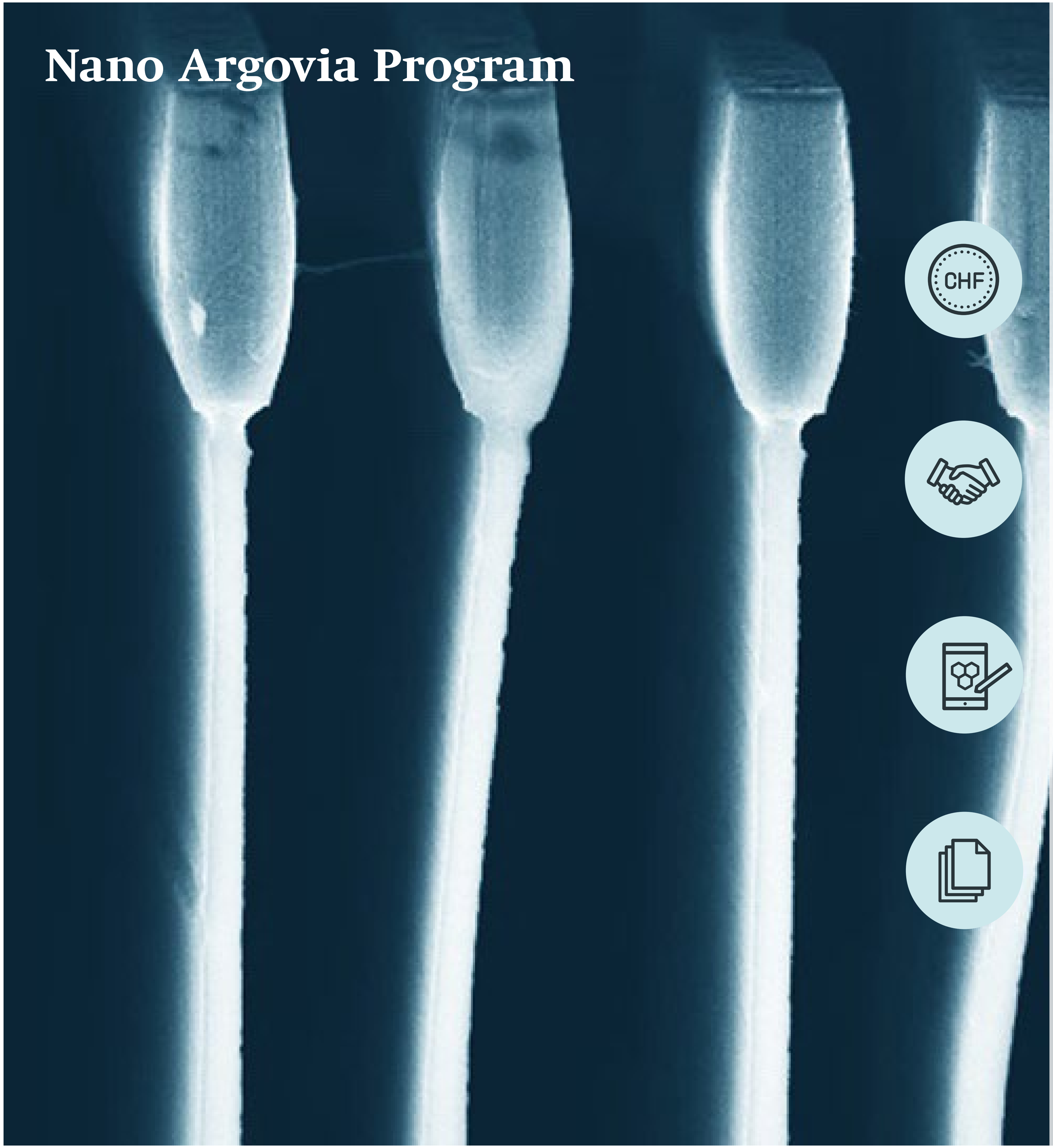
Quantum spin ices are crystalline materials in which the intrinsic angular momenta (spins) of the electrons in the various ions highly fluctuate even at very low temperatures close to absolute zero. Spin ice is of particular interest to scientists because it allows the observation of unusual phenomena, such as the formation of magnetic monopoles. These do not have north and south poles, as in a bar magnet, but rather a single pole resulting from interactions between a large number of spins. Based on theoretical calculations, the existence of magnetic monopoles was predicted many decades ago, but they were only realized experimentally in recent years.

Quantum mechanical effects

In 2018, in addition to the magnetic monopoles, Michel Kenzelmann's group also successfully demonstrated quantum mechanical spin ice effects in crystals of praseodymium hafnium oxide in collaboration with colleagues from the United Kingdom and Japan.

Quantum effects in the spin ice lead to new types of electric fields that are coupled with the magnetic monopoles and that fluctuate together. The resulting electromagnetic fields have similar properties to those of light and allow the formation of quantum-coherent states in which distant spins remain entangled with one another. The discovery is a step toward identifying novel materials that could pave the way for a new generation of quantum electronics.

Nano Argovia Program



1.4 Mio.

In 2018, the Nano Argovia program received CHF 1.4 million in funding from the SNI.

3

Each Nano Argovia project brings together at least three partners – two from research institutions in the SNI network and one from an industrial company in Northwestern Switzerland.

11

In 2018, seven new projects were launched and four projects were extended, one of them on a cost-neutral basis.

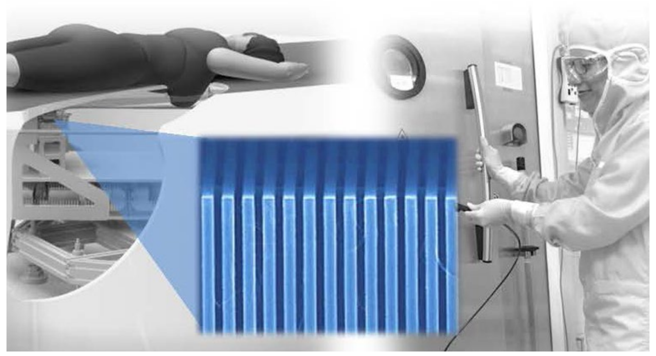
9+25

The Nano Argovia program led to the publication of nine scientific papers as well as 25 talks.

Scanning electron microscopic image of a silicon grating. This X-ray grating was realized by using metal assisted chemical etching. (Image: Lucia Romano ETH Zurich & Paul Scherrer Institute)

New projects in applied research

The year 2018 saw the launch of seven new projects as part of the Nano Argovia program, with four partner companies from the Canton of Aargau and three from Basel. The range of research topics reflects the diversity of the SNI network and demonstrates the potential value of collaboration with the SNI for companies in Northwestern Switzerland.



The new gratings are intended to improve the high-contrast imaging of female breast tissue. (Image: GratXray AG)

Using gratings to boost contrast – The Nano Argovia project NANOCREATE aids the optimization of diagnostic images

In the Nano Argovia project NANOCREATE, scientists from the Paul Scherrer Institute (PSI), in collaboration with the University of Applied Sciences Northwestern Switzerland (FHNW) and GratXray AG (Villigen, AG), are developing a cost-effective fabrication method for optical X-ray gratings. These gratings are used in a computed tomography (CT) scanner developed by GratXray that allows for high-resolution, high-contrast imaging of low-absorbing tissues, such as the female breast.

“The Nano Argovia project NANOCREATE will help us make grating interferometry available for a broad range of applications.”

Dr. Martin Stauber, CEO GratXray AG (Villigen, AG)

Nanoparticles for mega power – The MEGAnanoPower project aims to optimize an innovative energy storage device

In the Nano Argovia project MEGAnanoPower, scientists from the FHNW School of Life Sciences, the CSEM in Muttenz, and the industrial partner Aigys AG (Othmarsingen, AG) are working on the development of a battery (PowerCell®) originally invented by Aigys.

The PowerCell® is a special redox flow battery in which the charge carriers are not in solution. Instead, high-pressure technology is used to disperse them into the electrolytes in the form of small particles measuring just a few nanometers in diameter. As part of the project, the team is studying how these nanoparticles can help optimize the energy density. The researchers are therefore using eco-friendly, sustainable and cost-effective materials to optimize an environmentally compatible energy storage device for large-scale applications.

“It’s very inspiring to be part of the team behind the Nano Argovia project MEGAnanoPower. The team’s complementary skill sets have allowed us to overcome a number of obstacles.”

Andreas Schimanski, CEO Aigys AG (Othmarsingen, AG)

Messenger RNA in the crosshairs – The Nano Argovia project ecamist aims to improve single-cell analysis

Given that many biological phenomena cannot be investigated based on a large number of mixed cells, the technique of single-cell analysis is becoming increasingly important. The Nano Argovia project ecamist is developing an effective method for working up messenger RNA from single cells.

A team of scientists from the School of Life Sciences at the University of Applied Sciences Northwestern Switzerland (FHNW), the Department of Biosystems Science and Engineering at ETH Zurich in Basel (D-BSSE), and the company Memo Therapeutics AG (Basel) is improving the yield of isolated messenger RNA relative to that of existing methods.

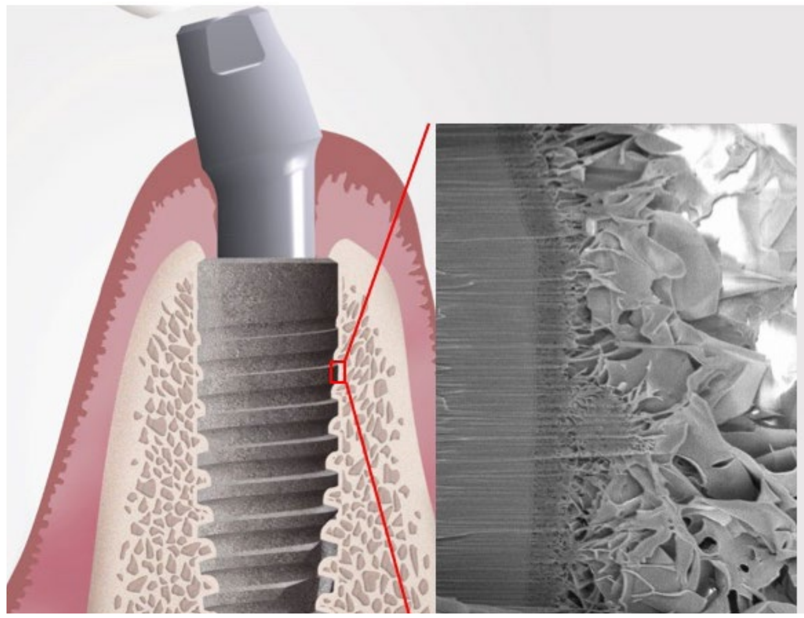
Among other applications, the information about the messenger RNA present in a cell can be used to derive conclusions about the development of diseases. It is also important for studying cell lines used in antibody production, for example.

“At Memo Therapeutics, we’re delighted with this highly effective collaboration. Now, we’re investigating how the newly developed technology can be integrated into our own platform for single-cell analysis.”

Dr. Simone Schmitt, Head Antibody Development, Memo Therapeutics AG (Basel)

“The findings obtained by the Nano Argovia project NanoCoat prove that the applied method has huge potential for improving the short- and long-term integration of dental implants into bone.”

Philipp Gruner, CEO Medicoat AG (Mägenwil, AG)



Coating implants with calcium phosphate ceramics will make it easier to integrate them into bone. (Image: Paul Scherrer Institute and Hager & Meisinger GmbH)

Bone implants – A cost-effective process is being developed in the Nano Argovia project NanoCoat

In the Nano Argovia project NanoCoat, an interdisciplinary team from the Paul Scherrer Institute (PSI) and the University of Applied Sciences Northwestern Switzerland (FHNW) is working alongside three industrial partners (Medicoat AG, Mägenwil; Atesos Medical AG, Aarau; and Hager & Meisinger GmbH, Neuss, Germany).

The researchers are developing a protocol for coating titanium implants with calcium phosphate ceramics, which will improve the integration of implants into new bone growth and therefore ensure greater stability of the implant.

Lightweight and stable – The Nano Argovia project NanoTough is investigating new methods for improving the toughness of composite materials

In the Nano Argovia project NanoTough, scientists from the University of Applied Sciences Northwestern Switzerland (FHNW), the University of Basel, and the company Huntsman Advanced Materials GmbH (Basel) are investigating the use of block copolymers in composite materials.

Their aim is to make composites tougher and thereby to improve their fracture properties while retaining a good level of workability.

Alessandro Napoli of Huntsman Advanced Materials GmbH wants to make composite materials tougher without impairing their workability. (Image: Huntsman Advanced Materials)

"By participating in the Nano Argovia project NanoTough, we are expanding our knowledge of new composite materials and hope to further consolidate our leading position in this area."

Dr. Alessandro Napoli, Global Technology Manager, Huntsman Advanced Materials GmbH (Basel)

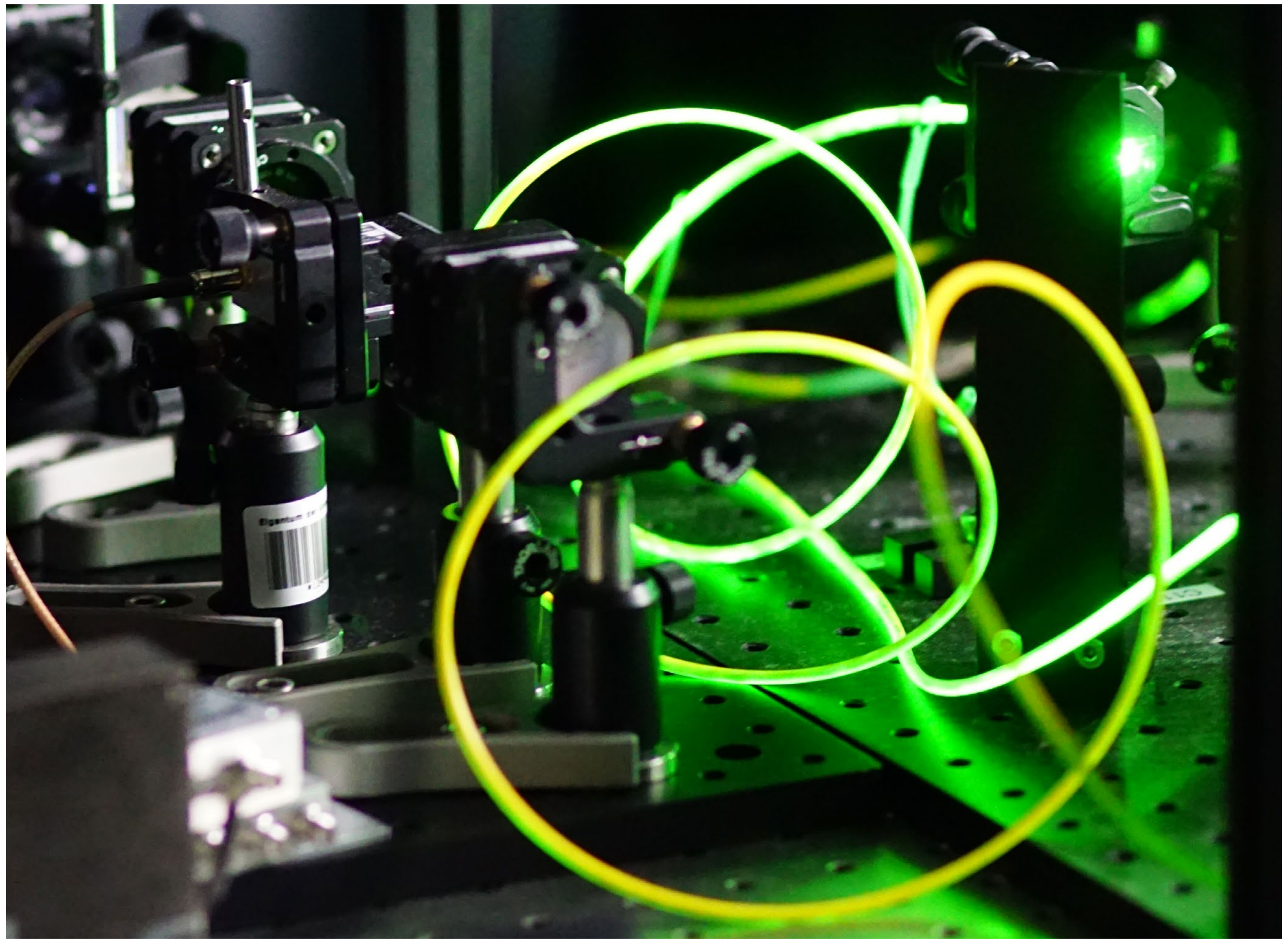
Detecting tiny changes using biosensors – The Nano Argovia project NanoGhip is developing a prototype of a biochip for drug discovery

In the Nano Argovia project NanoGhip, an interdisciplinary team from InterAx Biotech AG (Villigen, AG), the Paul Scherrer Institute (PSI), and the Department of Chemistry and Biozentrum at the University of Basel is investigating a new screening method for active substances that could lead to the discovery of new medicines.

The scientists aim to develop a new type of biochip that analyzes how the chemical and biological molecules in question react with protein complexes in real time. Even at this early stage, it could also provide information about the safety profile of the tested compounds.

"In this project, we've brought together a unique combination of experts that allows us to exploit synergies and explore a new approach to the biological screening of substances on a chip."

Dr. Martin Ostermaier, CEO InterAx Biotech AG (Villigen, AG)



Qnami, a young start-up from the University of Basel, is developing highly sensitive quantum sensors based on color centers in tiny diamonds.

Improving light yield – The Nano Argovia project NQsense seeks to optimize the sensitivity of quantum sensors for nanoscale applications

In the NQsense project, a team of scientists from Qnami, the Department of Physics at the University of Basel, and the Paul Scherrer Institute (PSI) is fabricating a fully integrated quantum sensor with significantly improved sensitivity. This sensor could be used, for example, to support fundamental research in the area of materials science or to perform failure analysis in the semiconductor industry.

The researchers are basing their analyses on tiny quantum sensors made of diamonds that have color centers in their crystal lattice, causing them to react sensitively to electric and magnetic fields.

"The Nano Argovia program offers the ideal framework for our product's further development, as we can exploit synergies with our partners at the University of Basel and the Paul Scherrer Institute. We've successfully relocated fabrication from Basel to the clean rooms of the PSI, thereby paving the way for industrial applications on a larger scale."

Dr. Mathieu Munsch, CEO Qnami (Basel)

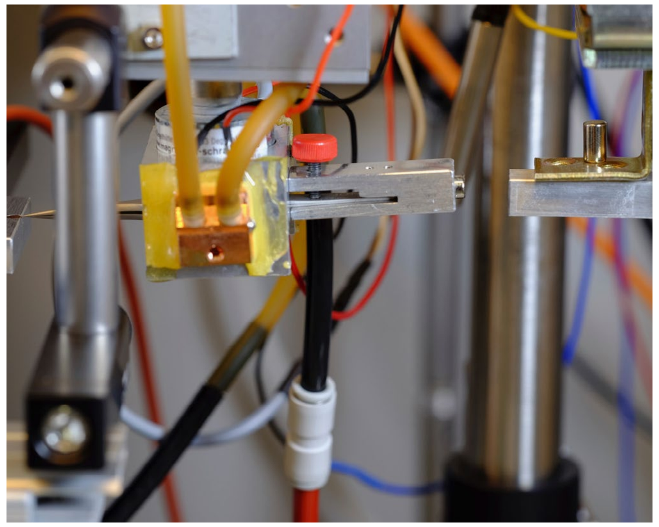
Extended projects in applied research

Four Nano Argovia projects originally launched in 2017 were extended to 2018, allowing the four teams to continue pursuing their applied lines of research in collaboration with their industrial partners.

Rapid workup of proteins for analysis – The Nano Argovia project MiPIS is laying the foundation for rapid sample preparation for cryo-electron microscopy

In the MiPIS project, scientists from the C-CINA (Biozentrum, University of Basel) and the FHNW School of Life Sciences have been working alongside their industrial partner leadXpro (Villigen, AG) to develop a system for the workup and preparation of protein samples prior to analysis with cryo-electron microscopy (cryo-EM).

The traditional workup methods for proteins are not always appropriate for the requirements of cryo-EM because they are time-consuming, require large quantities of protein, and sometimes disrupt the spatial arrangement of the protein complexes. Now, the scientists in the MiPIS project have developed a microfluidic system that meets the requirements of cryo-EM.



Cryo-electron microscopy only needs small quantities of material. With the development of the cryoWriter, the team has adapted the sample workup process so that it meets the requirements. (Image: C-CINA, University of Basel)

“Thanks to MiPIS, we can now obtain better and faster results with cryo-EM.”

Prof. Michael Hennig, CEO leadXpro (Villigen, AG)

Patient-specific and tailored to conditions in the mouth – The Nano Argovia project 3D Cellophil® membrane aims to develop innovative nanostructured implants

In this project, the researchers are developing a triple-layered polymer membrane based on the Cellophil® technology developed by CIS Pharma. The membrane supports the regeneration of bone and soft tissue in the jaw and mouth area and can be custom-built for each patient using 3D printing techniques.

Scientists from the FHNW School of Life Sciences and the Hightech Research Center of Cranio-Maxillofacial Surgery at University Hospital Basel are working on this in partnership with CIS Pharma AG (Bubendorf, BL). They provide the three layers of the implant with different properties so that they are perfectly adapted to conditions in the mouth.

“The project Cellophil® membrane is an example of a highly successful collaboration between industry and academia. We’re optimistic that we’ll soon have a prototype ready for preclinical trials.”

Dr. Christian Geraths (CIS Pharma AG, Bubendorf, BL)

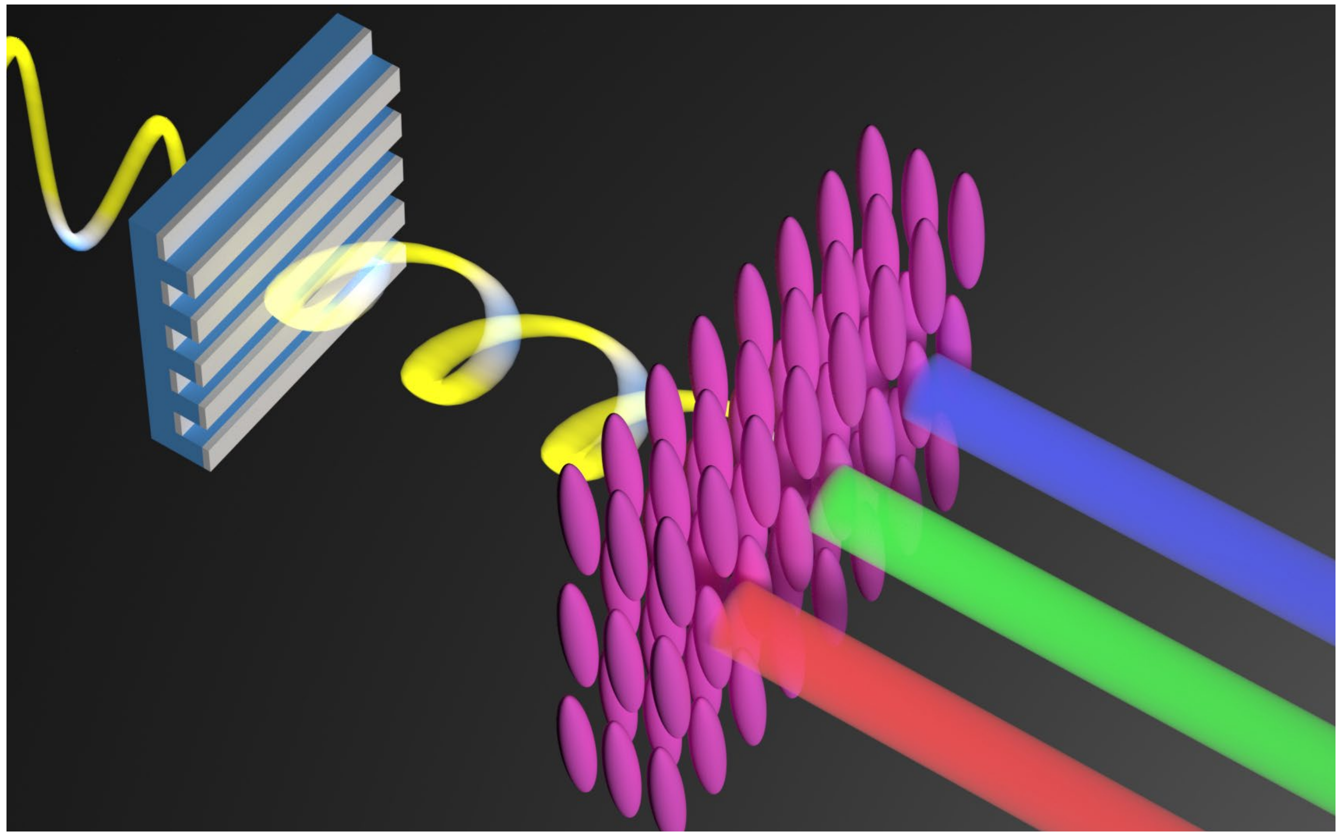
PlasmoRetarder – electrically controlled colors

In the Nano Argovia project PlasmoRetarder, researchers at CSEM in Muttenz and the Paul Scherrer Institute in Villigen are working with industrial partner Rolic Technologies Ltd. (Allschwil) to develop a plasmonic phase retarder which can be used for displays in sensor technology and imaging applications.

On the surface of nanostructured metals, electrons can be excited to collective oscillations known as surface plasmons. These plasmonic nanostructures are able to focus light at the nanoscale and to influence its color, phase and polarization. As a result, they can be used, for example, as color filters with outstanding resolution and a wide range of applications.

“We see huge potential in the Nano Argovia project PlasmoRetarder, which is translating highly innovative discoveries from basic science into industrial applications in the area of displays, optical films, and organic electronics.”

Richard Frantz, Leiter Development Optical Film Formulations, Rolic Technologies Ltd., Allschwil (BL)



Special nanostructured surfaces in combination with liquid crystals are able to influence the color, phase and polarization of light. (Image: CSEM Muttenz)

Rapid determination of three-dimensional structures

Nano Argovia project A3EDPI meets with a positive response

The team behind the Nano Argovia project A3EDPI have made a breakthrough in the determination of nanocrystal structures. Scientists working with Dr. Tim Grüne from the Paul Scherrer Institute recently published details of how they use electron nanocrystallography to determine the three-dimensional structure of active pharmaceutical ingredients in powder form. The publication, in the journal “Angewandte Chemie”, triggered a huge response from the scientific community and various pharmaceutical companies.

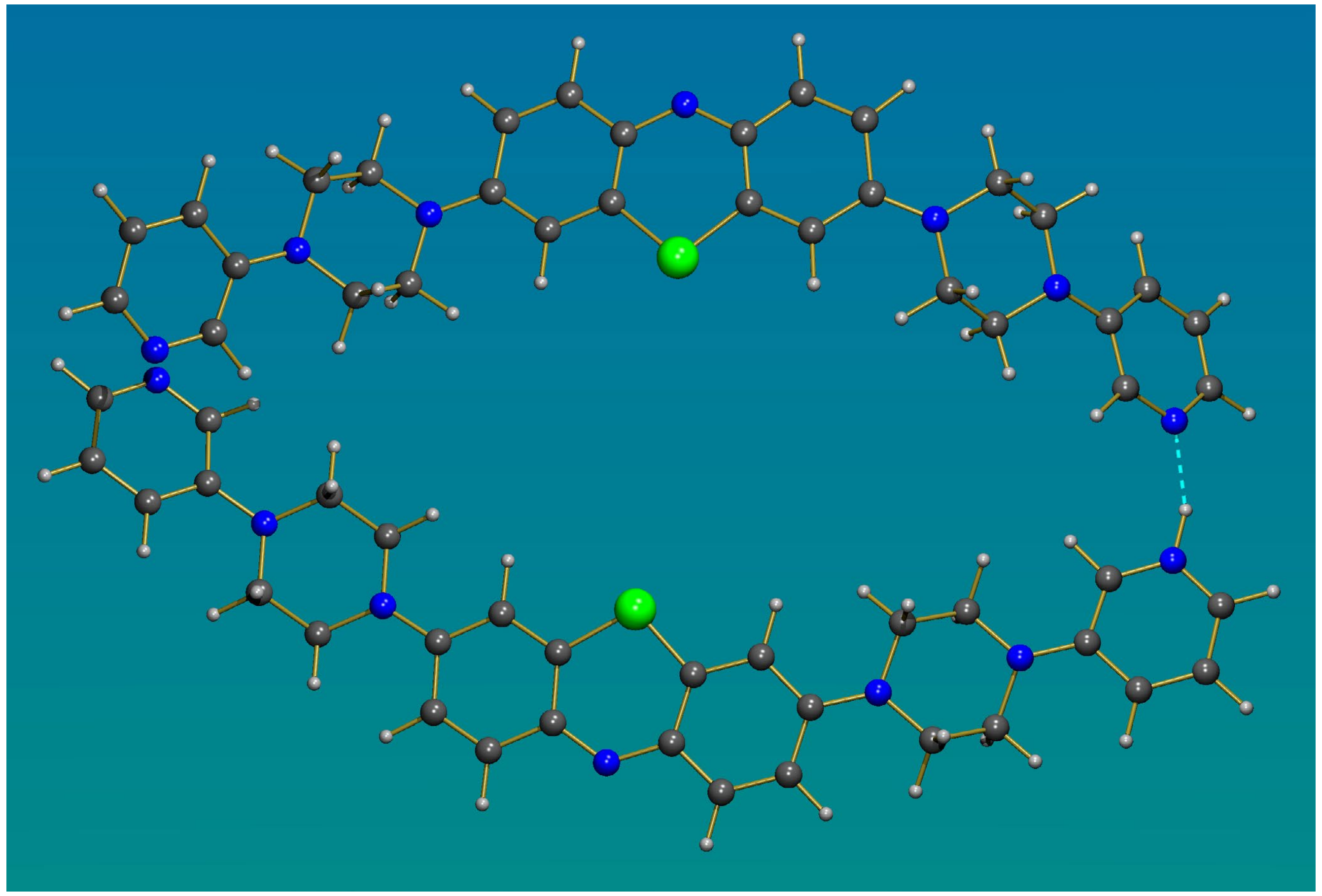
Powder is hard to analyze

To develop new active pharmaceutical ingredients efficiently and to obtain a license for their use, researchers need to know the exact three-dimensional structures of the substances, since the efficacy of a compound depends on its spatial configuration. If the active substances exist as individual crystals, the 3D structure can be determined using X-ray structure analysis. In many cases, however, the scientists have to work with powders – in other words, mixtures of crystalline nanograins measuring just 100–500 nanometers across. Until now, reliably analyzing their 3D structure required a great deal of time and instrumentation.

Electron beams reveal three-dimensional structure

As part of the Argovia project A3EDPI, an interdisciplinary team of scientists from the Paul Scherrer Institute (PSI), the University of Basel, and ETH Zurich collaborated with the companies Dectris AG and Crystallise! AG to investigate whether electron nanocrystallography is suitable for determining the 3D structure.

Tim Grüne is optimistic that the bottleneck in the analysis and identification of new active substance candidates can be bypassed with the help of electron nanocrystallography.



Thanks to the preparatory work, Tim Grüne was able to display the structure of methylene blue on a screen in just a few hours. (Image: Tim Grüne)

“We couldn’t have hoped for a better outcome. Excellent results published in respected journals are our best form of advertising.”

Dr. Sacha De Carlo, Business Development Manager, Dectris AG (Baden-Dättwil, AG)

“We expose the samples to a high-energy beam of electrons,” explains project leader Dr. Tim Grüne (PSI). “As the electrons have wave properties, each molecule produces a highly specific diffraction pattern depending on the arrangement of the atoms, and this allows us to draw precise conclusions regarding the atomic structure.”

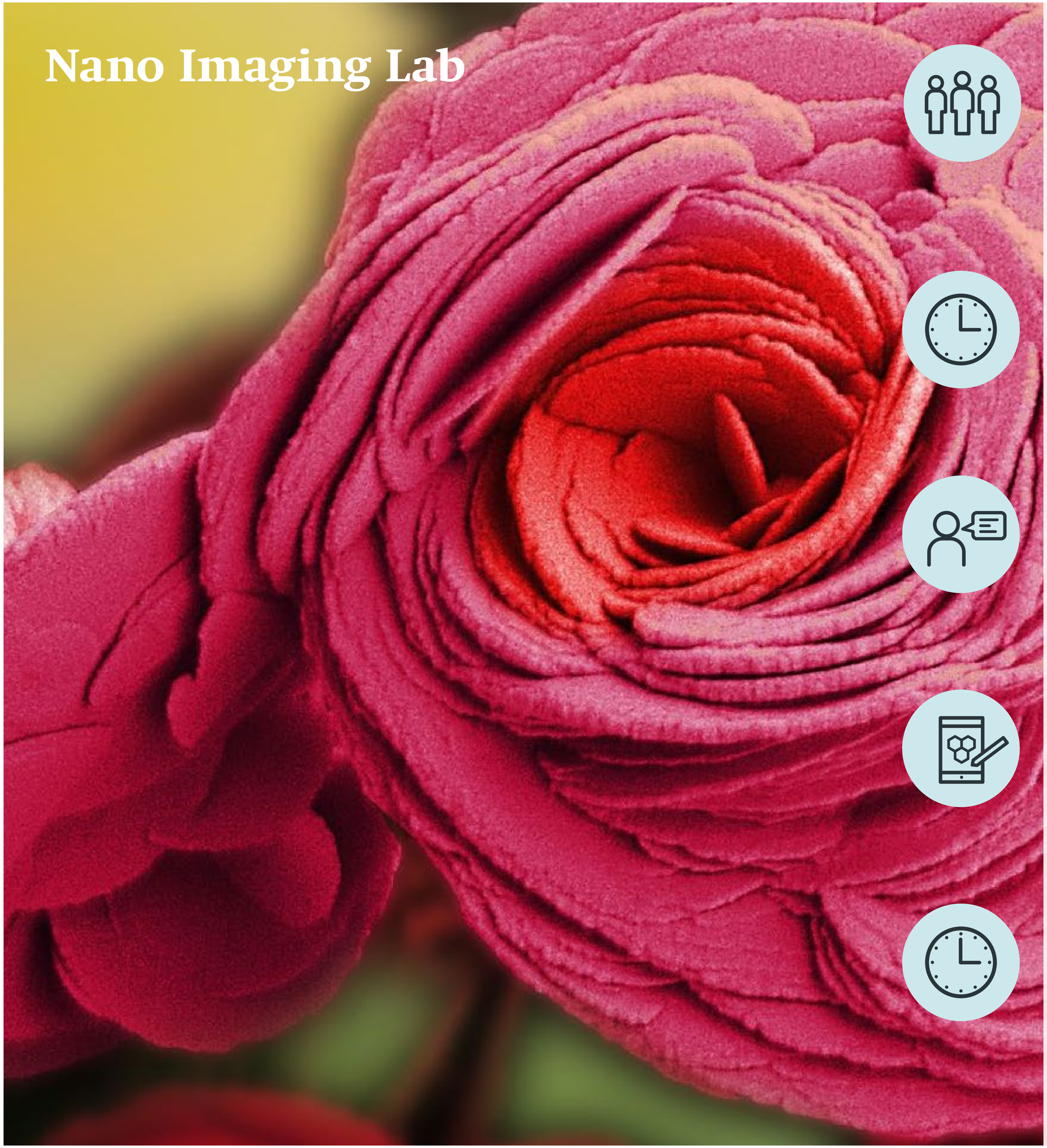
To begin with, the scientists developed a prototype of an electron diffractometer. Here, they combined an EIGER hybrid pixel detector from Dectris with a transmission electron microscope (TEM). As a test substance, they then analyzed the cold medicine Grippostad©, which contains a mixture of crystalline and non-crystalline, active and inactive components.

Also suitable for complex structures

“The small size of the crystals in this powder would prevent X-ray analysis from delivering satisfactory results,” explains Tim Grüne. “Using electron diffraction, however, we were able to identify the active substance unambiguously as acetaminophen, also known as paracetamol.” Electron beam diffraction can also successfully determine the structure of larger and more complex chemical compounds, as the researchers have demonstrated using a new, unknown derivative of methylene blue.

Tim Grüne worked as a senior scientist at the PSI until the end of the year before taking over responsibility for X-ray structure analysis at the University of Vienna’s Faculty of Chemistry. He is confident that the method will soon find a wide range of applications. The response from the scientific community supports the view that electron beam diffraction is ideally suited to determining the structures of extremely small crystals. Journals such as "Science" and "Nature" have picked up on the topic and asked Grüne for interviews. In addition, various pharmaceutical companies have expressed their interest in the method, “which may allow them to bypass the bottleneck in the analysis and identification of new active substance candidates,” explains Tim Grüne.

Nano Imaging Lab



5

At the Nano Imaging Lab, a team of five experienced, expert staff work to fulfill customer requests as well as advising on and researching a variety of topics.

3500

The various microscopes in the Nano Imaging Lab were working about 3500 hours.

62

In 2018, the NI Lab worked for 62 different customers.

135

The Nano Imaging Lab was involved in 135 projects in 2018.

2500

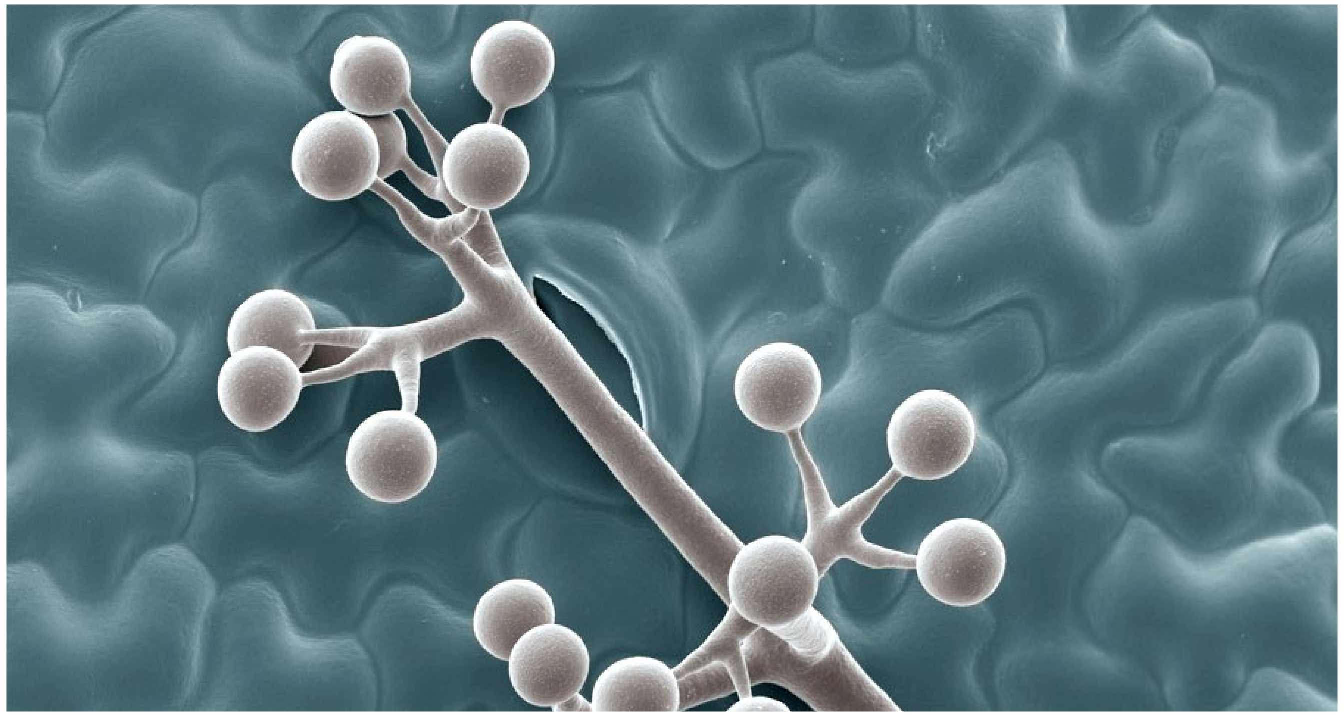
In 2018, the Nano Imaging Lab spent about 2500 hourse supervising students and preparing block courses as well as training customers in the use of high-tech microscopes.

Scanning electron microscopic image of a catalyst for the production of maleix anhydride (Image: Daniel Mathys, Nano Imaging Lab, University of Basel)

Long-lasting pest control

Images from the Nano Imaging Lab offer valuable insights

For many years, the Nano Imaging Lab (NI Lab) at the Swiss Nanoscience Institute of the University of Basel has been involved in research projects to support sustainable viticulture. For this work, the team led by Dr. Markus Dürrenberger collaborates primarily with the State Viticulture Institute in Freiburg, Germany, as part of the Interreg project Vitifutur in order to study the causes and development of fungal infections of vines and grapes. In 2018, the NI Lab took part in two meetings of viticulture experts to encourage cross-border collaboration in the Upper Rhine region and an exchange of experience among the Swiss partners in Northwestern Switzerland.



Downy mildew causes considerable damage to the viticulture industry. With fungi-resistant ("Piwi") grape varieties, infections can be prevented using far smaller quantities of fungicide. (Image: Evi Bieler, Nano Imaging Lab, University of Basel)

Scientific meeting of Vitifutur partners

In June 2018, the Nano Imaging Lab hosted the project partners from the Interreg project Vitifutur, which brings together leading research institutions from Switzerland, Germany, and France on a joint mission to study innovative approaches to long-lasting plant protection in the viticulture sector of the Upper Rhine region.

At the meeting, the researchers discussed how climate change – in combination with globalization and consumer demand for sustainably produced foods – presents winegrowers with an entirely new set of challenges. They are confronted not only with a steady stream of newly introduced pests, but also with growing consumer rejection of the widespread use of fungicides and pesticides.

Infection mechanisms

Among other things, researchers must now seek to clarify how and when infections occur and develop, and the electron microscope images produced by the NI Lab deliver useful information about these processes. For example, it is possible to show that the microfungus botrytis cannot infect grapes until the end of the ripening period, when cracks form in the waxy layer covering their surfaces. The condition of the grape skin also has a key influence on microfungal infections, as these ongoing studies demonstrate.

The Nano Imaging Lab will also be involved in BoVitis, a follow-up project to Vitifutur set to be launched in 2020. As part of BoVitis, researchers plan to study the genetic basis of natural resistance to botrytis, as well as the species-specific stability of grape surfaces. The aim will then be to breed resistant species, as has already been done with downy mildew. This is another microfungus that causes considerable damage to the viticulture industry and is traditionally kept in check using fungicides. However, studies presented at the meeting showed that fungi-resistant grape varieties allow a reduction by up to 75% in the use of phytosanitary treatments, depending on the variety and weather conditions.

Setting up a Swiss network

Whereas the Vitifutur meeting at the NI Lab in Basel focused on scientific studies and findings, the discussions at the Ebenrain Center for Agriculture, Nature, and Food in Sissach in November 2018 were primarily about establishing links between the Swiss partners in the various Interreg viticulture projects.

This initial meeting brought together Swiss representatives from the Interreg projects Vitifutur, VitiMeteo, AgroForm, InvaProtect, and BoVitis, as well as the viticulture commissioners of the cantons of Basel Landschaft and Aargau.

Speaking about the event, Dr. Markus Dürrenberger, head of the NI Lab, said: "We plan to set up a network in which we can exchange knowledge on a regular basis with a view to better meeting the present and future challenges facing the viticulture sector."

The microfungus botrytis cannot infect a grape until cracks have formed in the waxy layer. (Image: Evi Bieler, Nano Imaging Lab, University of Basel)

"The detailed images from the Nano Imaging Lab provide us with vital information about infection mechanisms and the development of infestations with various pests."

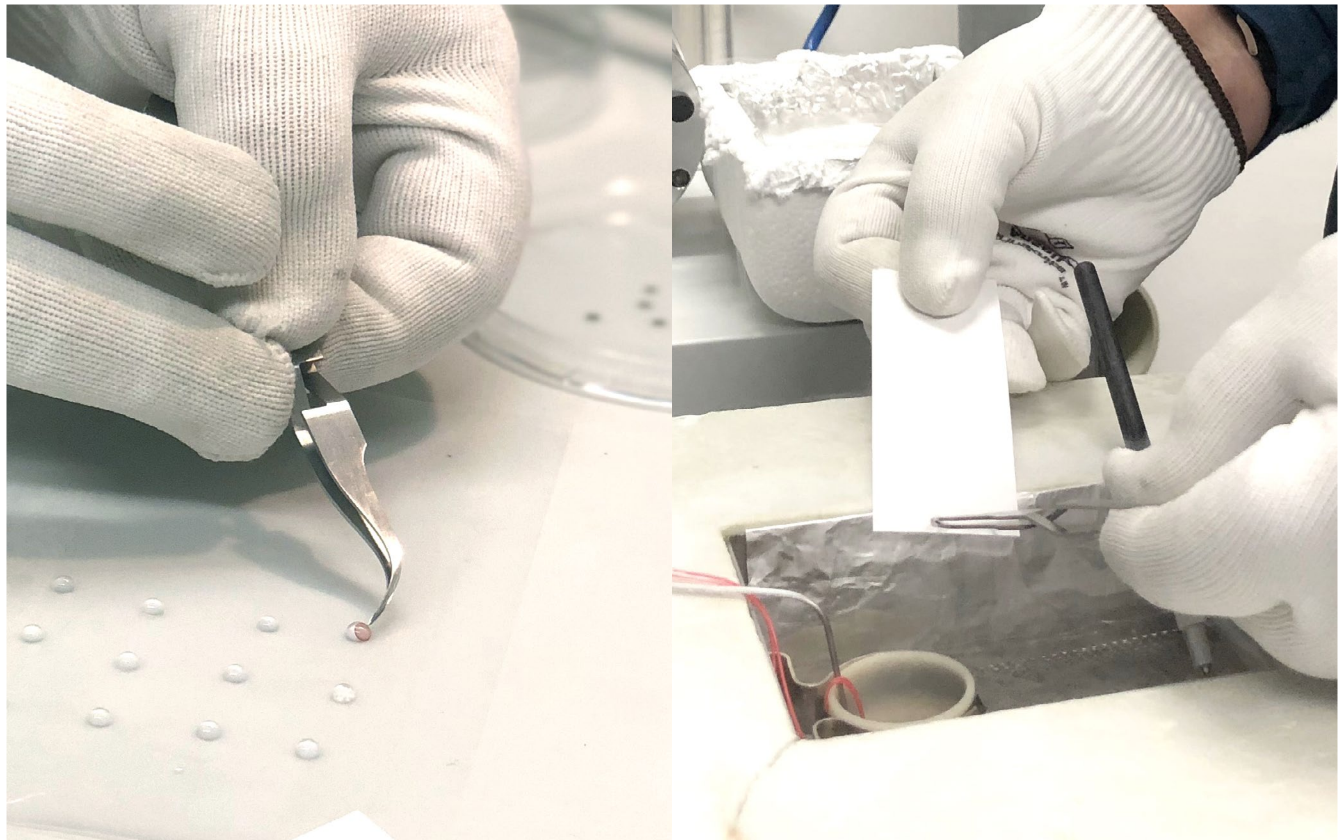
Dr. Hanns-Heinz Kassemeyer, State Viticulture Institute, Freiburg (Germany)

Development and application of new methods
Even more capabilities for customers

The team at the Nano Imaging Lab (NI Lab) is constantly expanding its portfolio of sample preparation and microscopy techniques to offer customers the best possible service. As of 2018, this extensive range of capabilities now includes freeze drying in order to prepare electron microscopy samples. In a seminar for NI Lab partners, the team also demonstrated new methods that use micromechanical techniques and ion etching to cut and polish samples and prepare them for microscopic analysis.

Excellent contrast and gentle preparation techniques
For decades, freeze drying has been used as a gentle way to prepare samples. The water contained in cells is first frozen and then converted directly from the solid to the gas state in a vacuum in order to eliminate it. At the Nano Imaging Lab, freeze drying is now combined with the ultra-fast freezing process for which Jacques Dubochet was awarded a Nobel Prize in 2017.

For this, the NI Lab invested in a new freeze dryer. The method begins with a flash-freezing process lasting just a few milliseconds, so that even sensitive biological materials retain their natural structure almost exactly. In the process, water contained within the cells does not form ice crystals but rather adopts a glass-like state, which sublimates under high vacuum in the subsequent drying process. This boosts the contrast between cell constituents and their environment, leading to significantly better microscope images. The NI Lab team has optimized this preparation process and adapted it to the requirements of the various types of microscope so that this elegant and gentle sample preparation method is now available to all partners.



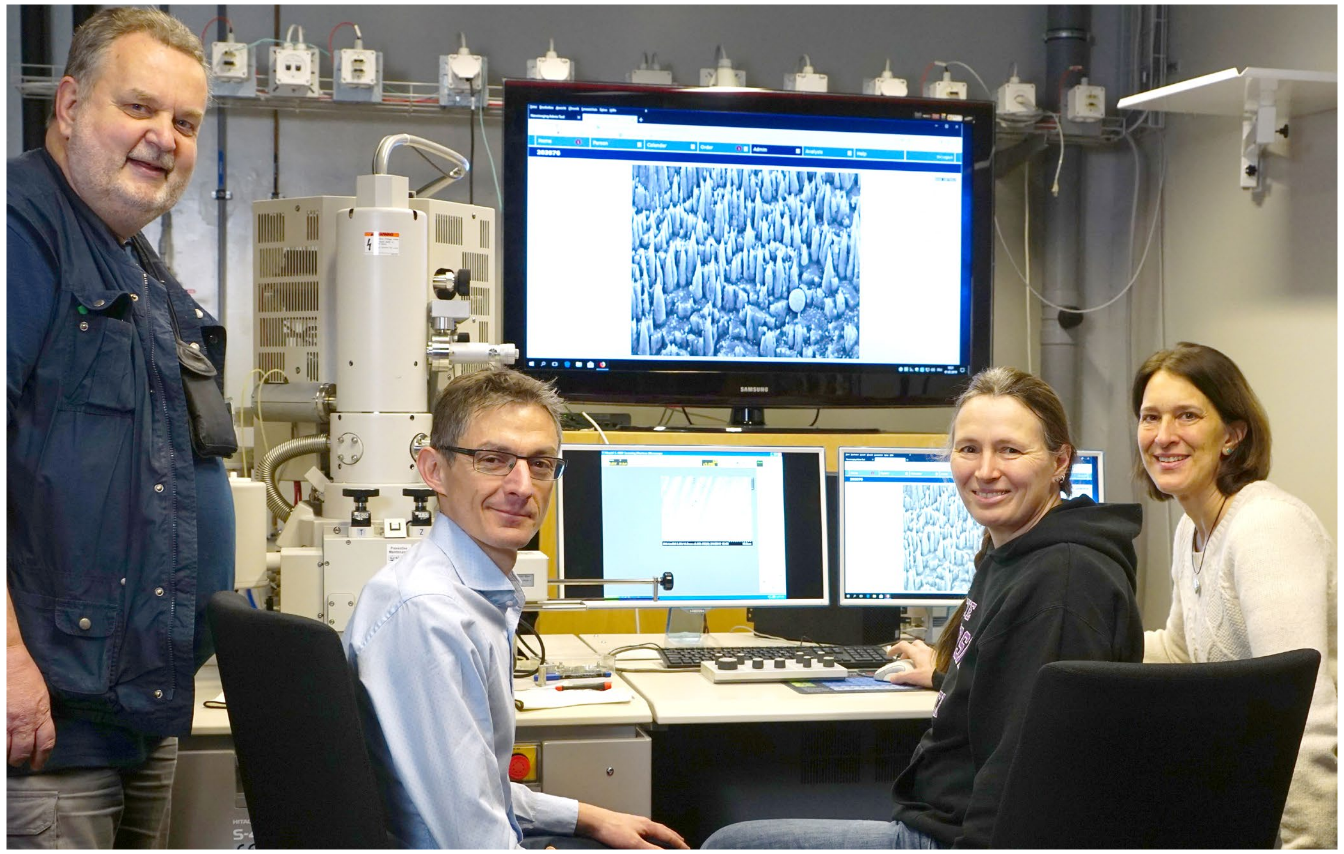
The tiny substrates are washed in a buffer solution and then immersed in liquid propane, causing the water in the cells to adopt a glass-like state. Structures within the cells are retained.

> “Freeze drying represents a key step forward in terms of retaining the structure of our samples. As a result, we’re able to visualize the layer structure of nanoparticles without interference from the preparation process.”

Gabriele Persy, Research Assistent, Department of Chemistry, University of Basel

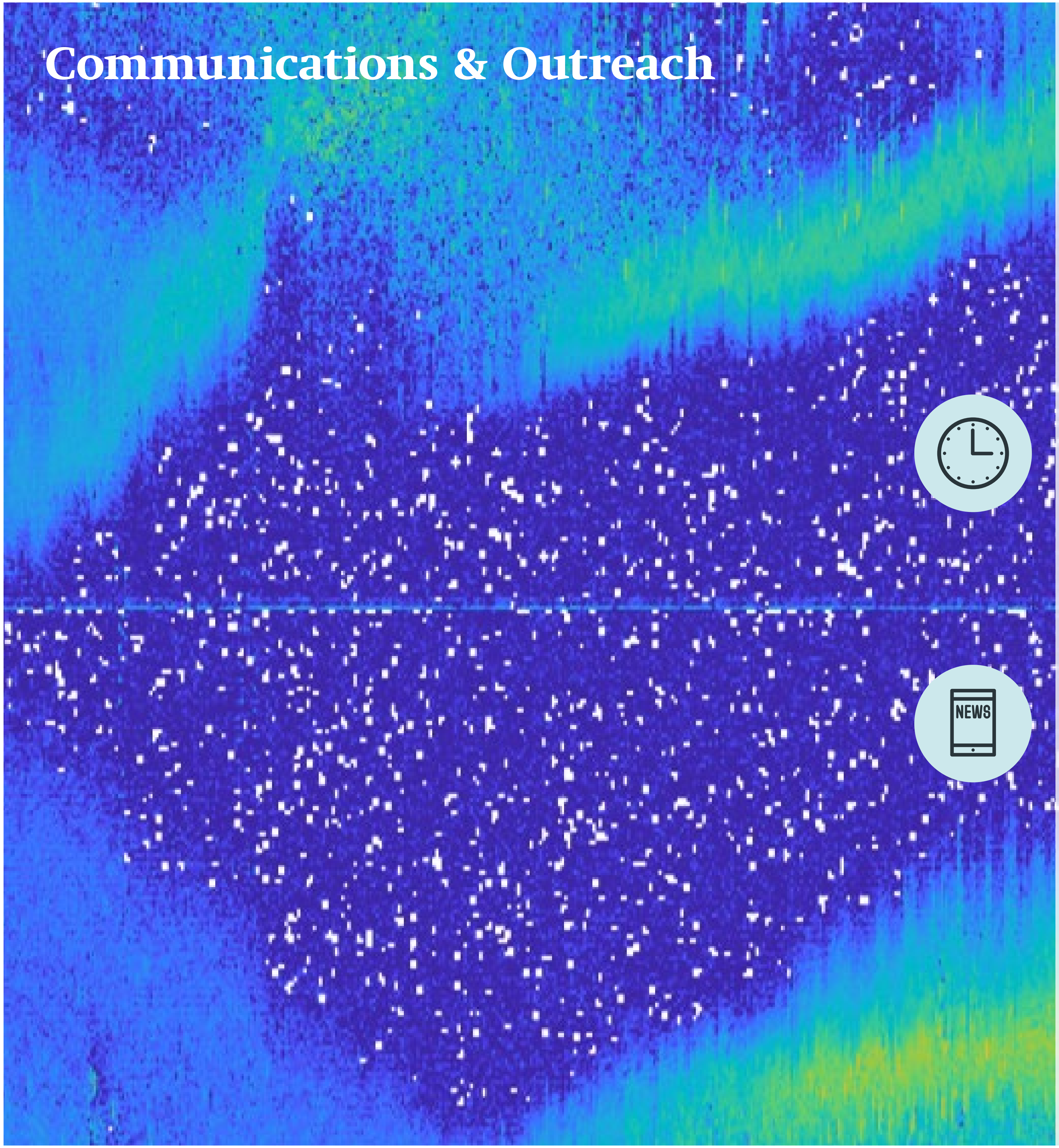
A wide range of ion etching capabilities
The Nano Imaging Lab is able not only to image existing structures on the nanometer scale, but also to uncover nanostructures in samples using micromechanical cutting and ion polishing techniques. To demonstrate the capabilities of ion etching to customers, the NI Lab and Leica Switzerland organized a joint workshop in 2018 with a view to presenting both theoretical and practical aspects of ion etching.

The twelve participants had the opportunity to cut and polish various materials using a micromechanical cutting tool and an argon plasma cutter. Subsequent analysis using a scanning electron microscope could then be used, for example, to examine the grain-size distribution in different layers of the material.



Laurent Marot (second from left) from the Department of Physics has been a satisfied customer of the Nano Imaging Lab for many years.

Communications & Outreach



> 350

In 2018, the SNI outreach team spent over 350 hours engaging closely with pupils, teachers, and interested adults with the assistance of students, doctoral researchers, and the staff of the Nano Imaging Lab. The SNI participated in 30 outreach events.

> 220

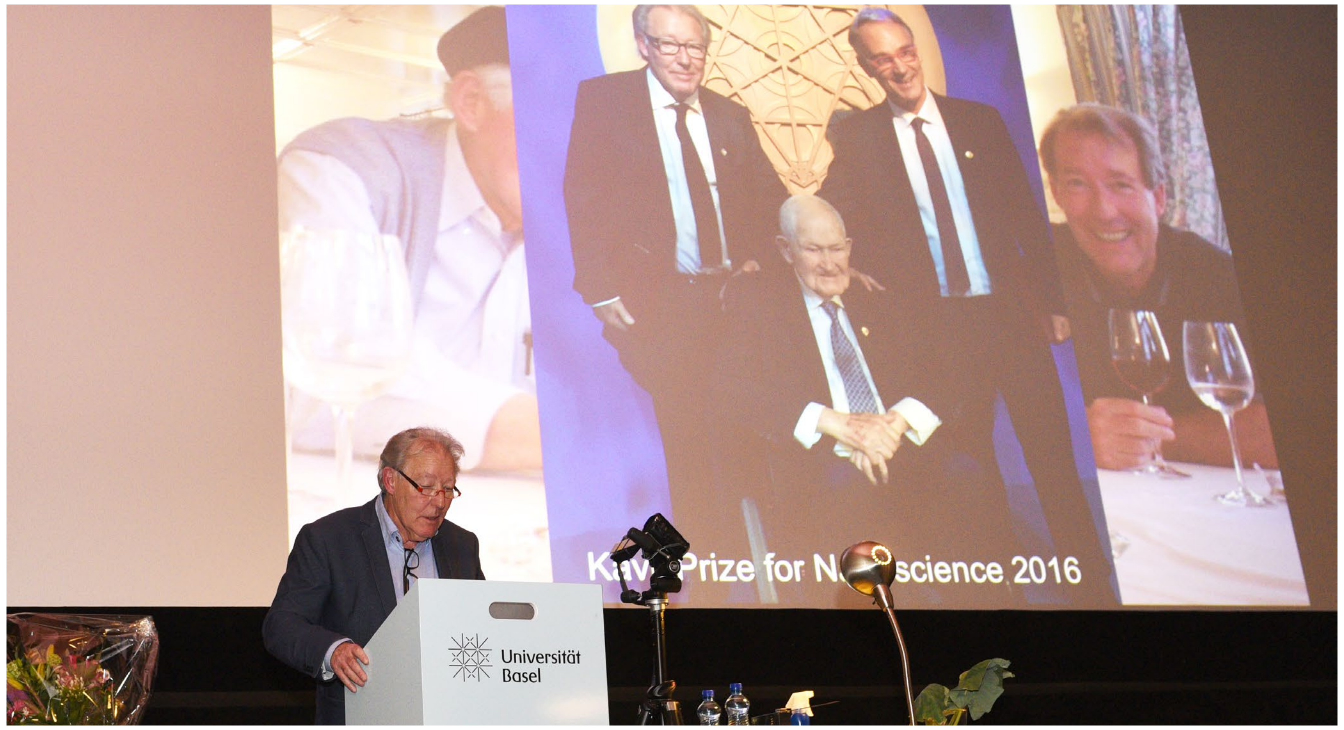
In 2018, we collected more than 220 media reports about the SNI's research and activities. For the most part, these were based on the fourteen press releases drafted by the SNI in collaboration with the communications department of the University of Basel.

Stability diagram of 5-atom-wide armchair graphene nanoribbons contacted via graphene electrodes. (Image: Maria El Abbassi, Jan Overbeck, Department of Physics, University of Basel and Empa)

SNI communication
The right message for different target groups

The SNI has a small communications and outreach team that keeps the public informed about nanoscience research at the SNI. In doing so, it must take account of differences between the various target groups. It is important not only to inform scientists within the network about the latest research findings, but also to inspire children, young people, and the wider public about the natural sciences and bring them closer to the multifaceted world of nanoscience research. The SNI team rises to this challenge through a variety of media and events.

Nano on the big screen
A movie night with a twist saw 80 guests from the worlds of politics and academia embark on a voyage of discovery into the nanoworld at the Oris cinema in Liestal. The evening was organized by the University of Basel and the Swiss Nanoscience Institute in honor of Professor Christoph Gerber, who developed the atomic force microscope with two of his colleagues over 30 years ago. For this work, he has received honors including the prestigious Kavli Prize, which is considered the Nobel Prize for nanoscience. This entertaining evening provided guests with an overview of how the technology came to be developed and how it is put to use in many areas of modern research.



Christoph Gerber talks about how the development of the atomic force microscope came about over 30 years ago and how he and his two colleagues received the Kavli Prize for their work. (Image: University of Basel)

"We want to address various target groups and inform them about the fascinating world of nanoscience in an entertaining way."

Dr. Kerstin Beyer-Hans, Sandra Hüni, Dr. Christel Möller & Dr. Michèle Wegmann
SNI communications team

Jacques Dubochet captivated his audience with a talk on how he began his career at the Biozentrum many years ago and on the process of developing cryo-electron microscopy, for which he was awarded a Nobel Prize.

A fascinating talk by Nobel laureate Jacques Dubochet
A mini-symposium organized jointly by the SNI and the Biozentrum provided a largely academic audience with the opportunity to hear from Nobel laureate Professor Jacques Dubochet in person. Together with his colleagues Ueli Aebi and Andreas Engel, Dubochet led an audience of well over 300 people on a journey into the world of cryo-electron microscopy, for whose development he was awarded a Nobel Prize in 2017.

Thanks to the invention of shock freezing, biological samples can be frozen instantly in their natural environment to avoid the formation of ice crystals, which would destroy the sample. Even in the vacuum present in an electron microscope, the shock-frozen samples remain intact and can be analyzed in detail.

"It was wonderful to witness the enthusiasm of Jacques Dubochet, Ueli Aebi, and Andreas Engel and to see how they inspired the many students and scientists present in the audience."

Prof. Christian Schönenberger, moderator of the SNI/Biozentrum Lecture with Jacques Dubochet

At the market and the community college
The SNI took part in two events to help people from the region learn about nanoscience and its activities. The first consisted of an SNI stand at the May market in Lenzburg, offering visitors a wealth of information and activities.

For the second, the SNI put together a nanosciences program for the "SamstagsUni" series of courses offered by the community college Volkshochschule beider Basel. Over four Saturdays, numerous SNI members introduced the participating seniors to a range of nanoscience topics.

The wheel of fortune was a major attraction at the May market in Lenzburg.

Brochures for current and prospective students

As a targeted way of addressing young people interested in studying nanosciences, the SNI produced two new brochures in 2018: an overview of the nanosciences degree course at the University of Basel and a graduate brochure highlighting examples of the numerous avenues open to nanoscience graduates. In both brochures, readers hear from young students themselves and get a sense of their enthusiasm for this interdisciplinary degree course.

"Visits to the SNI are always very informative and provide pupils with a fantastic insight into current research."

Dr. Brian Cutting, physics teacher at FG Basel secondary school

Making research accessible

The SNI addresses older pupils through its participation in the TecDays and TecNights, which are organized by the Swiss Academy of Engineering Sciences (SATW). In 2018, the two outreach managers, Dr. Michèle Wegmann and Dr. Kerstin Beyer-Hans, appeared at a total of six events to continue their "Big Bang Goes Nano" program, which they redesigned in 2017. At these events, they explain examples from research into graphene and Parkinson's disease, and help pupils develop a taste for research themselves by participating in related experiments.

In 2018, the SNI once again welcomed school groups for visits to the SNI and a tour of the laboratories to see what everyday life is like for a researcher. During the visits by five school classes, the outreach team was supported primarily by doctoral students, who gave talks reflecting the diversity of nanoscience research.

Furthermore, at a teacher event in collaboration with other departments from the faculty, the SNI presented teachers from the region with information on current research topics.

Pupils from the Alte Kantonsschule in Aarau visited the SNI in spring 2018.

Learning through play

Activities are the best way to engage children aged 8 to 14, and the Science Days at Europa-Park Rust are a great opportunity to do just that. Every year, the SNI has a booth at Germany's oldest science festival, which attracts around 18,000 visitors over three days and is dedicated to scientific experiments and questions.

The 2018 event was themed around water. At the SNI booth, children and adults alike learned about the purification of liquids and the lotus effect. Visitors had the opportunity to produce pure, clear water using a variety of filters and to make lotus flowers from crêpe paper.

The SNI was also involved in various activities organized by the University of Basel, such as the UniKidsCamp during summer vacation and the Future Day in November, which also used play to help children gain an understanding of the sciences.

Students from the nanoscience study program were on hand to help visitors make their own lotus flower.

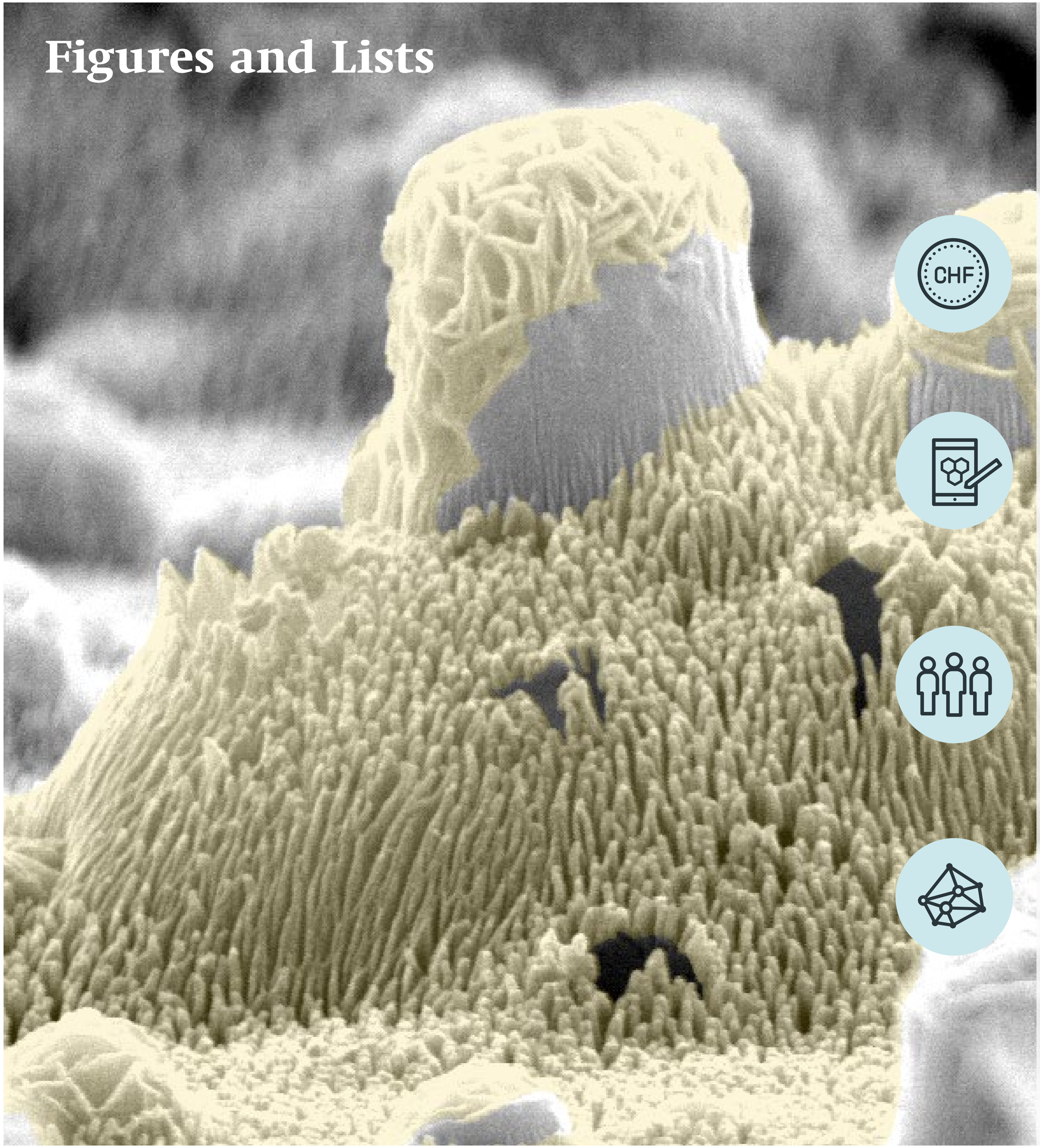
Applied research at the Nano-Tech Apéros

In 2018, the SNI relaunched its series of events in relation to the Nano Argovia program, providing partners from research institutions and industry with an opportunity to stay informed and exchange ideas. These Nano-Tech Apéros are also a chance for scientists and industry representatives to find out about the SNI's program of applied research and make new contacts.

In February, the Nano-Tech Apéro brought together over 40 nanotechnology experts at BRUGG Flex in Brugg. In November, DSM in Kaiseraugst was a perfect host to some 50 participants, who learned about current Nano Argovia projects from a series of talks and posters and took the opportunity to discuss new lines of research.

At the Nano-Tech Apéro, the emphasis is on the exchange of ideas between academia and industry.

Figures and Lists



7.25 Mio.

In 2018, the SNI had a budget of 7.25 million Swiss Francs, of which 4.5 million came from the Canton of Aargau and 2.75 million from the University of Basel.

52

The SNI supported 52 research projects, 11 in the applied Nano Argovia program and 41 in the SNI PhD School.

145

In 2018, the SNI had 145 members.

8

Eight partner institutions belong to the SNI network. This includes the University of Basel, the School of Life Sciences at the University of Applied Sciences Northwestern Switzerland (FHNW), the School of Engineering of FHNW, the Paul Scherrer Institute (PSI), the Department of Biosystems Science and Engineering at the Federal Institute of Technology (ETH) Zurich in Basel, and the Centre Suisse d'Electronique et de Microtechnique (CSEM) in Muttenz. The Hightech Zentrum Aargau and BaselArea. swiss supplement the network.

Silver nanopillars grown by photoreduction on top of an Iron layer (Image: Luc Driencourt, CSEM Muttenz)

Financial report

The Swiss Nanoscience Institute (SNI) was founded at the University of Basel in 2006 on the initiative of the Canton of Aargau with a view to educating talented young people, gaining new insights through scientific research, and engaging in knowledge and technology transfer for the benefit of industry in Northwestern Switzerland. These pillars – teaching, basic research, applied research, and knowledge and technology transfer – are also reflected in the SNI's finances.

Focus on basic research

Basic research forms the foundation of all activities at the SNI and receives the largest share of funding. Accordingly, the SNI supports the two Argovia professors at the University of Basel, Professors Roderick Lim and Martino Poggio, and – to a lesser extent – the three titular professors from the PSI. In total, these funding measures for professors amount to some CHF 1.5 million. As in previous years, the two Argovia professors authored successful publications in respected scientific journals and made a key contribution to the SNI's outstanding reputation with their active participation in international conferences. As a result of their scientific excellence, Roderick Lim and Martino Poggio were able to secure a combined total of CHF 1.9 million in national and international third-party funding in 2018.

Funding for basic research also comes from doctoral students at the SNI PhD School, which was founded in 2012. The 41 doctoral students enrolled in the school as of 2018 work at various institutions in the SNI network – often in collaboration with multiple institutions – but will all earn their doctorates from the Faculty of Science at the University of Basel. In 2018, the SNI PhD School had a budget of CHF 1.9 million, which was used to finance the various dissertation projects.

Key role for knowledge and technology transfer

The knowledge acquired through basic research is passed on to industrial companies in Northwestern Switzerland, principally under the highly successful Nano Argovia program. The knowledge and technology transfer (KTT & PR) activities were supported with funding of approximately CHF 1.7 million in 2018.

Launched in 2007, the Nano Argovia program is tailored to the needs of industrial companies and is now very well established. This is reflected in the large number of submitted applications and in the positive feedback we receive from industry partners involved in past Nano Argovia projects. In 2018, funding was provided for eleven Argovia projects, six of which had an Aargau-based company as their industry partner. In addition to the contributions that the SNI receives from the Canton of Aargau and the University of Basel, project partners provided a total of CHF 1.7 million for the applied Nano Argovia projects via public research funding instruments, their own funds, and contributions by industrial companies.

Excellent service

The Nano Imaging Lab (NI Lab) has now been part of the SNI for a little over two years and was also integrated into the financial organization of the SNI in 2018. The NI Lab provides a valuable service and comprehensive imaging support for research projects. It analyzes nano samples and creates microscopy images (electron microscopy and scanning probe microscopy) for SNI members at inexpensive rates, as well as advising them on their research projects. In 2018, the NI Lab received about CHF 0.5 million in basic funding from the University of Basel. The ongoing operating and personnel costs exceeded this sum by approximately CHF 0.13 million, which was offset by income of CHF 0.15 million for services rendered.

Study and communication

In addition to the funding of professorships (Support), the PhD School, knowledge and technology transfer (KTT & PR), and the Nano Imaging Lab, the budget also includes items for Management & Overhead, Infrastructure (investment in premises and apparatus), Outreach (conferences, brochures, public events, and making contact with children and teenagers), and Nano Study (bachelor's and master's degree programs).

In 2018, there were 97 students enrolled on the nanoscience study program, of which 52 were registered on the bachelor's program and 45 on the master's program. This item is reflected in the budget with an expenditure of CHF 0.55 million. As nanoscience is not a subject taught at schools, it is vital for the SNI to approach pupils actively and to make them aware of this challenging degree program – which is still unique in Switzerland – at a variety of events. The SNI therefore invested approximately CHF 0.1 million in outreach and PR activities, which were largely implemented by representatives of the SNI management team.

A good balance

There is a very good balance between expenditure and income. The status of earmarked funds as per 31/12/2018 is almost identical to that of the previous year. Funds of over CHF 1.3 million that are already allocated but will not take effect until 2019 are to be subtracted from this balance. The actual balance therefore stands at approximately CHF 6.4 million.

The Canton of Aargau temporarily reduced its financial commitment by CHF 0.5 million, to CHF 4.5 million, for the years 2016–2018. In order to adjust the budget accordingly, the SNI has made cuts to various items and capped the number of newly funded dissertation projects to a maximum of seven per year. In the long term, this will reduce the number of doctoral students to 28 (compared to the current figure of 41) and result in savings of around CHF 0.5 million each year.

We would like to take this opportunity to thank the Office of Finance and Controlling at the University of Basel for its reporting activities. A special thank you goes to the Cantons of Aargau, Basel-Stadt, and Baselland for the support they give the SNI, allowing us to educate excellent young scientists, conduct research at the highest level, and pass on our findings to companies in the region.

The following table shows expenses for 2018 by category in accordance with the financial report of the University of Basel dated 25 February 2019.

Expenditure 2018 in CHF

		Univ. Basel	Canton AG	Total
Management	Personnel and operational costs	310'440	227'912	538'352
	Overhead	—	585'000	585'000
Infrastructure	Infrastructure building	—	—	—
	Infrastructure equipment	52'587	123'814	176'401
KTT & PR	Personnel and operational costs	97'595	147'247	244'843
	Argovia projects	—	1'434'960	1'434'960
Outreach	Operational costs	32'957	45'044	78'001
Support	Argovia professorships	535'951	833'930	1'369'881
	PSI-Professors	—	96'956	96'956
Nano Study	Bachelor and master program	298'348	250'234	548'583
Nano Imaging Lab	Personnel and operational costs	456'741	—	456'741
PhD School	Research projects	958'768	958'768	1'917'536
Total expenditure for 2018 in CHF		**2'743'387**	**4'703'866**	**7'447'253**

The following table shows the SNI balance sheet as at 31 December 2018.

SNI balance sheet 2018 in CHF

	Univ. Basel	Canton AG	Total
Grants	2'754'512	4'500'000	7'254'512
Investment income	26'352	170'629	196'981
Income	**2'780'864**	**4'670'629**	**7'451'493**
Expenditure	**2'743'387**	**4'703'866**	**7'447'253**
Balance year 2018	**37'477**	**-33'237**	**4'240**
SNI assets per 01/01/2018	**1'679'310**	**5'983'849**	**7'663'159**
Annual balance	37'477	-33'237	4'240
SNI assets per 31/12/2018 in CHF	**1'716'787**	**5'950'611**	**7'667'399**

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C. Zelmer, Biozentrum, University of Basel

Projects of the SNI PhD School

Call 2013

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1201 Microfluidics to study nano-crystallization of proteins (PhD finalized in 2017)	T. Braun (Univ. Basel), H. Stahlberg (Univ. Basel)	S. Arnold
P1202 Nanofluidic devices for biomolecules (PhD finalized in 2017)	Y. Ekinci (PSI), T. Pfohl (Univ. Basel)	M. Gerspach
P1203 On surface covalent assembly of coordination polymers with integrated read and write functions (PhD finalized in 2017)	C. Housecroft (Univ. Basel), T. Jung (PSI)	T. Nijs
P1204 Site-specific magnetic studies and control of large self-assembled spin systems (PhD finalized in 2016)	T. Jung (PSI), A. Kleibert (PSI)	J. Nowakowski
P1205 Watching the nanomachinery of the nuclear pore complex at work by high speed-AFM (PhD finalized in 2018)	R. Y. H. Lim (Univ. Basel), C. Gerber (Univ. Basel, NanoMotion)	Y. Sakiyama
P1206 Nanomechanical oscillators for diamond spin-optomechanics (PhD finalized in 2017)	P. Maletinsky (Univ. Basel), R. Warburton (Univ. Basel)	A. Barfuss
P1207 Design of a polymer membrane-based molecular «hoover» (PhD finalized in 2018)	W. Meier (Univ. Basel), D. Müller (D-BSSE)	R. Goers
P1208 Ultra-sensitive force detection and molecular manipulation (PhD finalized in 2017)	E. Meyer (Univ. Basel), M. Poggio (Univ. Basel)	M. Schulzendorf
P1209 Design of polymer nanoreactors with triggered activity (PhD finalized in 2017)	C. Palivan (Univ. Basel), J. Huwyler (Univ. Basel)	T. Einfalt
P1210 Bottom-up nanowires as ultra-sensitive force transducers (PhD finalized in 2018)	M. Poggio (Univ. Basel), R. Warburton (Univ. Basel)	D. Cadeddu
P1211 Ultraclean suspended graphene (PhD finalized in 2017)	C. Schönenberger (Univ. Basel), D. Zumbühl (Univ. Basel)	C. Handschin
P1212 Nano-photonics with diamond (PhD finalized in 2017)	R. Warburton (Univ. Basel), P. Maletinsky (Univ. Basel)	D. Riedel
P1213 Artificial metalloenzymes for molecular nanofactories (PhD finalized in 2017)	T. Ward (Univ. Basel), S. Panke (D-BSSE)	S. Keller
P1214 An ion-atom hybrid trap on a chip: synthesis and control of nanosystems on the single-molecule level (PhD finalized in 2018)	S. Willitsch (Univ. Basel), P. Treutlein (Univ. Basel)	I. Rouse
P1215 Nanostructure quantum transport at microkelvin temperatures (PhD finalized in 2017)	D. Zumbühl (Univ. Basel), D. Loss (Univ. Basel)	M. Palma

Call 2014

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1301 Energy dissipation over structural and electronic phase transitions (PhD finalized in 2018)	E. Meyer (Univ. Basel), M. Poggio (Univ. Basel)	D. Yildiz
P1302 Probing the initial steps of bacterial biofilm formation: dynamic and molecular principles of surface-based cell motility and mechanosensation (PhD finalized in 2018)	T. Pfohl (Univ. Basel), U. Jenal (Univ. Basel)	N. Sauter
P1303 Assembly and investigation of electrochemically triggered molecular muscles (PhD finalized in 2018)	M. Mayor (Univ. Basel), M. Calame (Univ. Basel)	Y. Aeschi
P1304 Folding mechanisms of beta-barrel outer membrane proteins and their catalysis by natural holdases and foldases	S. Hiller (Univ. Basel), D. Müller (D-BSSE)	N. Ritzmann
P1305 Towards X-FEL based dynamic studies on 2D and 3D nanocrystals of membrane proteins on solid supports (PhD finalized in 2018)	C. Padeste (PSI), H. Stahlberg (Univ. Basel)	N. Opara
P1306 Slow-release nano-pills for mosquitoes for interrupting malaria transmission	P. Hunziker (Univ.-Spital Basel), R. Brun (Tropeninstitut, Univ. Basel)	D. Gonçalves
P1307 Optoelectronic nanojunctions	M. Calame (Univ. Basel), M. Mayor (Univ. Basel)	J. Overbeck
P1308 Supramolecular charge and spin architectures produced by chemical clipping (PhD finalized in 2018)	P. Shahgaldian (FHNW), T. Jung (PSI)	M. Moradi
P1309 Cooling and control of a nanomechanical membrane with cold atoms	P. Treutlein (Univ. Basel), P. Maletinsky (Univ. Basel)	T. Karg
P1310 Plasmonic sensing in biomimetic nanopores	Y. Ekinci (PSI), R. Y. H. Lim (Univ. Basel)	D. Sharma

Call 2015

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1401 Targeted single cell proteomics using magnetic nanoparticles to study prion-like spreading of amyloid nanoparticles	T. Braun (Univ. Basel), H. Stahlberg (Univ. Basel)	C. Schmidli
P1402 Lightweight structures based on hierarchical composites	C. Dransfeld (FHNW), C. Schönenberger (Univ. Basel)	W. Szmyt
P1403 Tailor-made proteins and peptides for quantum interference experiments	V. Köhler (Univ. Basel), M. Mayor (Univ. Basel)	J. Schätti
P1404 Selective transport of functionalized nanocarriers into biomimetic and natural nuclear pore complexes	R. Lim (Univ. Basel), C. Palivan (Univ. Basel)	C. Zelmer
P1405 Surface-functionalization of diamond nano-magnetometers for applications in nano- and life sciences	U. Pieles (FHNW), P. Maletinsky (Univ. Basel)	M. Batzer
P1406 Charge transfer versus charge transport in molecular systems	O. Wenger (Univ. Basel), M. Calame (Univ. Basel)	S. Neumann
P1407 Coupling a single ion to a nanomechanical oscillator	S. Willitsch (Univ. Basel), M. Poggio (Univ. Basel)	P. Fountas
P1408 Clean zigzag and armchair graphene nanoribbons	D. Zumbühl (Univ. Basel), D. Loss (Univ. Basel)	M. Rehmann

Call 2016

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1501 Nanomechanical mass and viscosity measurement-platform for cell imaging	T. Braun (Univ. Basel), E. Meyer (Univ. Basel)	P. Oliva
P1502 Investigating individual multiferroic and oxidic nanoparticles	A. Kleibert (PSI), M. Poggio (Univ. Basel)	D. M. Bracher
P1503 Watching giant multienzymes at work using high-speed AFM	T. Maier (Univ. Basel), R. Y. H. Lim (Univ. Basel)	S. Singh
P1504 Valleytronics in strain-engineered graphene	C. Schönenberger (Univ. Basel), M. Calame (Univ. Basel)	L. Wang
P1505 A programmable e-beam shaper for diffractive imaging of biological structures at Å resolution	S. Tsujino (PSI), J. P. Abrahams (Univ. Basel)	P. Thakkar

Call 2017

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1601 Optical plasmonic nanostructures for enhanced photochemistry	E. Constable (Univ. Basel), S. Fricke (CSEM Muttenz)	L. Driencourt
P1602 Self-assembly and magnetic order of 2D spin lattices on surfaces	T. A. Jung (Univ. Basel), J. Dreiser (PSI)	M. Heydari (Beginn 2018)
P1603 A mechano-optical microscope for studying force transduction in living cells	R. Lim (Univ. Basel), E. Meyer (Univ. Basel)	T. Kozai (Beginn 2018)
P1604 Selective reconstitution of biomolecules in polymer-lipid membranes	W. Meier (Univ. Basel), U. Pieles (FHNW)	S. Di Leone
P1605 Topological electronic states in metal-coordinated organic networks	M. Muntwiler (PSI), T. A. Jung (Univ. Basel)	D. Sostina
P1606 Smart peptide nanoparticles for efficient and safe gene therapy	C. Palivan (Univ. Basel), J. K. Benenson (D-BSSE, ETHZ Basel	S. Tarvirdipour
P1607 Understanding and engineering of phonon propagation in nanodevices by employing energy resolved phonon emission and adsorption spectroscopy	I. Zardo (Univ. Basel), C. Schönenberger (Univ. Basel)	L. Gubser

Call 2018

Project	Principle Investigator (PI) and Co-PI	PhD Student
P1701 Van der Waals 2D semiconductor nanostructures with superconducting contacts	A. Baumgartner (Univ. Basel), C. Schönenberger (Univ. Basel)	M. Ramezani
P1702 Single organelle size sorting by a nanofluidic device	Y. Ekinci (PSI), H. Stahlberg (Univ.Basel)	T. Mortelmans
P1703 Quantum sensing of nanomechanical systems	P. Maletinsky (Univ. Basel), P. Treutlein (Univ. Basel)	
P1704 Evolving Protease Enzymes with New Sequence Specificity using Peptide-Hydrogel Cell Encapsulation	M. Nash (Univ. Basel), S. Reddy (D-BSSE, ETHZ Basel)	J. López Morales
P1705 Genetic selection of nanocatalysts	S. Panke (D-BSSE, ETHZ Basel), T. Ward (Univ. Basel)	E. Rousounelou
P1706 Ultrasensitive Force Microscopy and Cavity Optomechanics using Nanowire Cantilevers	M. Poggio (Univ. Basel), F. Braakman (Univ. Basel)	D. Jäger
P 1707 Nano-photonics with van der Waals heterostructures	R. Warburton (Univ. Basel), I. Zardo (Univ. Basel)	L. Sponfeldner

Nano Argovia projects

Projects started in 2018

Project	Project leader	Project partner
A13.01 NANOCREATE: NANOCatalyst etching and laser machining for grating interferometry based breast ct system	K. Jefimovs (PSI)	L. Romano (PSI & ETHZ), R. Holtz (FHNW), B. Resan (FHNW), M. Stauber (GratXray AG, Villigen), Z. Wang (GratX-ray AG, Villigen)
A13.04 ecamist – Efficient capturing of mRNA for single-cell transcriptomics	G. Lipps (FHNW)	M. Held (ETHZ Basel, D-BSSE), S. Schmitt (Memo Therapeutics AG, Basel)
A13.08 MEGAnanoPower – Disruptive power storage technology applying electrolyte nano dispersions and micro/ nano structured electrodes	U. Pieles (FHNW)	S. Fricke (CSEM Muttenz), A. Schimanski (Aigys AG, Othmarsingen)
A13.09 NanoCoat – Biomimetic growth of calcium phosphates ceramics on Ti implants	A. Testino (PSI)	E. Müller (PSI), M. de Wild (FNHW), P. Gruner (Medicoat AG, Mägenwil), J. Moens (Medicoat AG, Mägenwil), W. Moser (Atesos Medical AG, Aarau), B. Höchst (Hager & Meisinger GmbH, Neuss)
A13.12 NanoGhip – Nano-switchable GPCR–arrestin biochip for drug discovery	M. K. Ostermaier (InterAx Biotech AG, Villigen)	G. Schertler (PSI), C. Palivan (Univ. Basel), R. Y. H. Lim (Univ. Basel)
A13.13 NanoTough – Self-assembled block copolymers for nanoscale toughening of structural composite materials	S. Neuhaus (FHNW) C. Dransfeld (FHNW)	W. Meier (Univ. Basel) A. Napoli (Huntsman, Basel)
13.15 NQsense – Nanophotonics for quantum sensing technology	P. Maletinsky (Univ. Basel)	C. David (PSI), G. Seniutinas (PSI), F. Favaro (Univ. Basel & QNAMI), M. Munsch (QNAMI)

Prolonged projects

(with and without financial support)

Project	Project leader	Project partner
A12.01 A3EDPI: Applicability of 3D electron diffraction in the pharmaceutical industry	T. Grüne (PSI)	E. van Genderen (PSI), J. P. Abrahams (Univ. Basel), S. De Carlo (Dectris AG, Baden-Dättwill)
A12.10 MiPIS: Microfluidic protein isolation, stabilization and cryo-EM preparation for high-resolution structural analysis	T. Braun (Univ. Basel)	M. Hürzeler (FHNW), M. Chami (Univ. Basel), M. Hennig (leadXpro, Villigen)
A12.13 PlasmoRetarder: Plasmonic nanoscale retarder controlled with liquid crystals	B. Gallinet (CSEM Muttenz)	Y. Ekinci (PSI), J. Dahdah (Rolic Technologies Ltd., Allschwil)
A12.17 3D Cellophil® membrane: 3D printable nano porose Cellophil® membranes with nano hydroxyapatite gradient for tissue regeneration applications	U. Pieles (FHNW)	S. Stübinger (HFZ, Univ. Basel), C. Geraths (CIS Pharma AG, Bubendorf)

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Matteo Fadel, Tilman Zibold, Boris Décamps, and Philipp Treutlein, *Spatial entanglement patterns and Einstein-Podolsky-Rosen steering in Bose-Einstein condensates*, Science (2018) https://doi.org/10.1126/science.aao1850

Roland Goers, Johannes Thoma, Noah Ritzmann, Alfredo Di Silvestro, Claudio Alter, Gesine Gunkel-Grabole, Dimitrios Fotiadis, Daniel J. Müller & Wolfgang Meier, *Optimized reconstitution of membrane proteins into synthetic membranes*, Communications Chemistry (2018) https://doi.org/10.1038/s42004-018-0037-8.

Page 9: Arne Barfuss, Johannes Kölbl, Lucas Thiel, Jean Teissier, Mark Kasperczyk, and Patrick Maletinsky, *Phase-controlled coherent dynamics of a single spin under closed-contour interaction,* Nature Physics (2018) https://doi.org/10.1038/s41567-018-0231-8

M. De Bardi, R. Müller, C. Grünzweig, D. Mannes, P. Boillat, M. Rigollet, F. Bamberg, T.A. Jung, K. Yanga, *On the needle clogging of staked-in-needle pre-filled syringes: Mechanism of liquid entering the needle and solidification process*, European Journal of Pharmaceutics and Biopharmaceutics (2018) https://doi.org/10.1016/j.ejpb.2018.05.006

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Scientific part of the Annual Report

If you are interested in detailed reports about the Nano Argovia and SNI PhD School projects, please scan the QR code or send us an email so that we can supply a printed version (c.moeller@unibas.ch).

Scientific part of the Annual Report

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