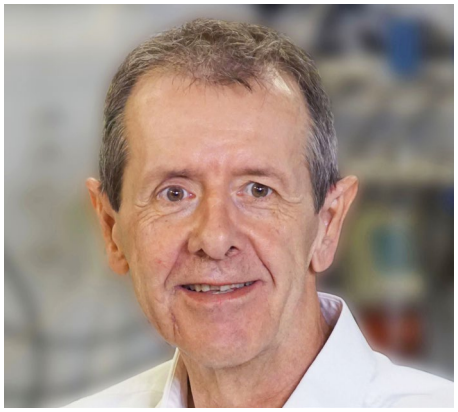
University of Basel

Swiss Nanoscience Institute

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

# SNI update December 2018



Dear colleagues,

As the year once again draws to a close, it is a good opportunity to take stock of the past 12 months.

By and large, it has been a good year for the SNI.

In the Nano Argovia program, we received a large influx of 19 new applications and five extensions. This clearly shows that our regional program for applied research in collaboration with industry is now firmly established, and that we are able to choose the very best and most promising projects. The SNI steering committee recently approved six new projects, which will get underway in 2019.

Eight new projects were approved for the SNI PhD School in 2018. We received applications from a large number of qualified candidates. This year also saw eight of our PhD candidates successfully complete their dissertations, and another candidate will have her thesis defense just before the holidays.

In order to summarize the results of the Nano Argovia and PhD School projects, we are already compiling the annual report – and I would like to take this opportunity to ask all those involved to submit their information in good time.

Having spread the word about a few success stories over the last year through press releases, our newsletter, the website or events such as the Nano-Tech Apéro, we also have some great news to share in this, the last SNI update of the year. My colleague from the Department of Physics, Professor Jelena Klinovaja, has been promoted to associate professor, and you will find a brief portrait of her in this SNI update.

In the cover story, we report on a publication by Tim Grüne and colleagues. This emerged from the Nano Argovia project A3EDPI and has seen a very positive media response over the last month.

At the end of the year, we were also delighted to learn that an R'Equip application has been approved for a new transmission electron microscope (TEM) at the Nano Imaging Lab. We will therefore conduct an evaluation over the coming months to determine exactly what requirements the new instrument must fulfil and then proceed with procurement in the course of next year.

Lastly, I would like to extend my sincere thanks to all those who have contributed to the success of the SNI through their work, ideas and suggestions, and who have helped our center of excellence for nanosciences in Northwestern Switzerland earn its outstanding reputation on the regional, national and international stage. I wish you a peaceful and relaxing holiday season and a happy, healthy and successful new year.

Warm regards,

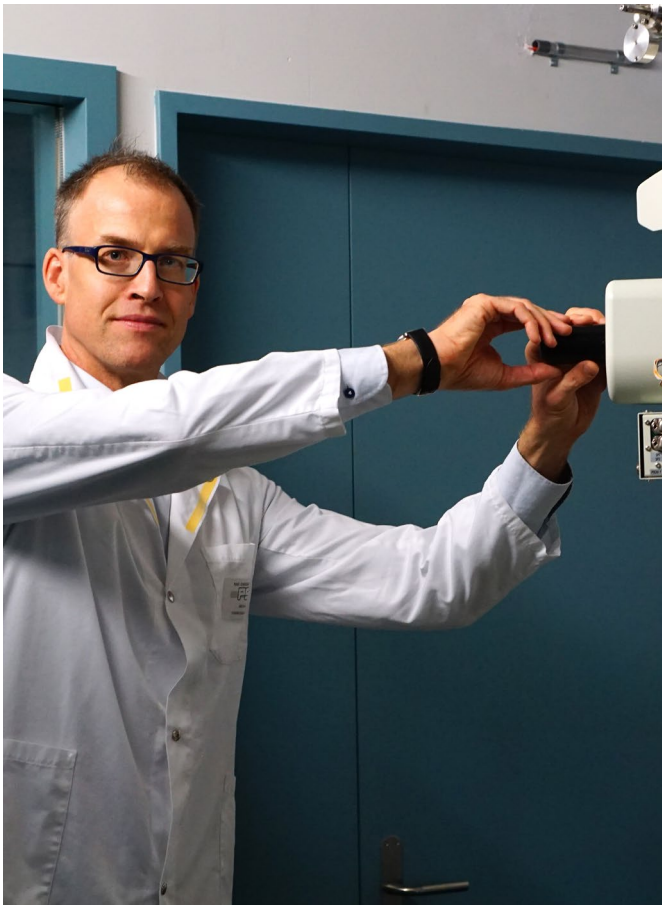
Christian Schönenberger

Prof. Dr. Christian Schönenberger
SNI Director

# Rapid determination of three-dimensional structures

## Nano Argovia project A3EDPI meets with a positive response

For over twelve years, the Swiss Nanoscience Institute (SNI) has supported applied research projects as part of the Nano Argovia program, providing companies in Northwestern Switzerland with access to innovative research through the SNI network. As these projects focus on applications that are useful to the companies, they rarely lead to publications in prominent scientific journals. The Nano Argovia project A3EDPI, led by Dr. Tim Grüne of the Paul Scherrer Institute (PSI), is an exception. Together with colleagues, Grüne recently published some initial results in the journal Angewandte Chemie, and their article triggered a huge response. In it, the scientists described how they successfully use electron nanocrystallography to determine the three-dimensional structure of active pharmaceutical ingredients in powder form.



Tim Grüne is optimistic that electron nanocrystallography will soon enjoy broad applications.

### 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

Now, 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 has collaborated with the companies Dectris AG and Crystallise! AG to investigate whether electron nanocrystallography is suitable for determining the 3D structure. “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. “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.

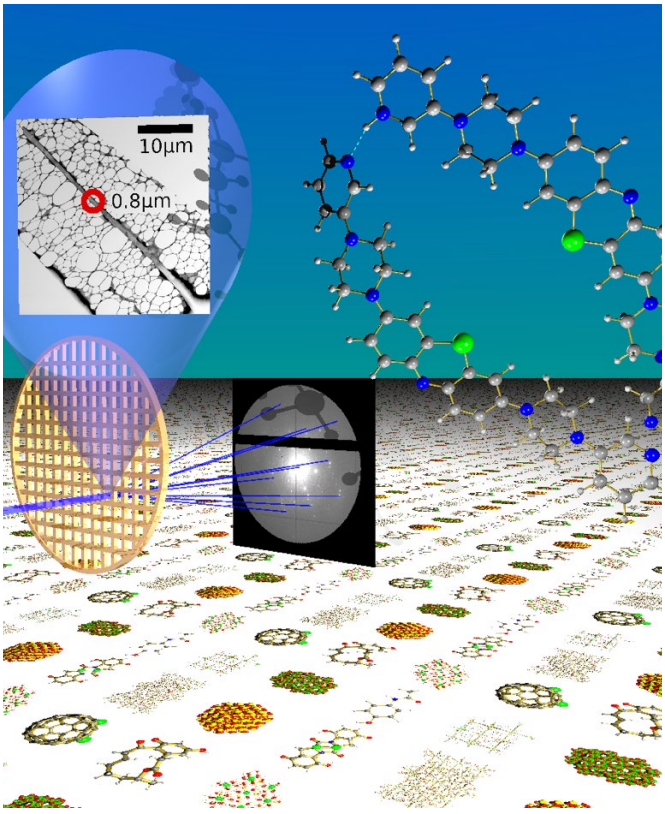
Tim Grüne, who is currently working as a senior scientist at the PSI, is certain that the method will soon enjoy broad applications. In an interview with the journal Science, he says: "Pharmaceutical companies build up huge collections of crystalline compounds for their drug screening activities, but only around a quarter to a third of these compounds form crystals that can be analyzed using X-ray crystallography. Our method may help to bypass this bottleneck in the analysis and identification of new active substance candidates, as we can analyze even the very small crystals – just a few hundred nanometers in size – for which no 3D structure currently exists."

Tim Grüne's phone is currently ringing round the clock, as scientific journals such as Science and Nature are keen to learn more about the method. For example, Nature recently published an article entitled "Why didn't we think to do this earlier? Chemists thrilled by speedy atomic structures," and the journal Science also believes that the method could significantly speed up the development of new drugs as well as forensic investigations (see links).

The Nano Argovia project A3EDPI will conclude at the end of 2018. However, Tim Grüne will continue to use electron-beam diffraction to determine structures – albeit not at the PSI. At the start of next year, he will take over responsibility for X-ray structure analysis at the University of Vienna's Faculty of Chemistry. Once there, he will hopefully continue his work on this successful approach, whose wide range of applications has now been demonstrated by the Nano Argovia project.

Original paper:
https://onlinelibrary.wiley.com/doi/abs/10.1002/anie.201811318

More information about the SNI's Nano Argovia program:
https://nanoscience.ch/de/forschung/angewandte-forschung/




On a grating for transmission electron microscopy (TEM), a tiny crystal of the methylene blue derivative is placed. The tiny crystals are irradiated with electrons (blue beam) and a typical diffraction pattern is created. Based on the specific information of the diffraction pattern, the scientists can determine the chemical structure of the molecule. Numerous structures are waiting to be identified using this new method (Image: Tim Grüne).

Links to articles in Science and Nature:

http://www.sciencemag.org/news/2018/10/new-day-chemistry-molecular-ct-scan-could-dramatically-speed-drug-discovery

https://nanoscience.ch/wp-content/uploads/sites/8/2018/10/nature_gruene.pdf

# Theory at the service of practice

In February 2019, Jelena Klinovaja will become an associate professor at the University of Basel's Department of Physics – ample reason for the SNI network to get to know the young professor and expert in condensed matter physics a little better.

Even as a child, Jelena Klinovaja was fascinated by mathematics and physics, taking part in numerous contests and olympiads. However, the disconnect she often felt between mathematical concepts and the real world led her to begin studying theoretical physics at the renowned PhysTech in Moscow in 2003. In 2009, after completing her master's degree, she moved to Basel to do a doctorate under Professor Daniel Loss, which she concluded with summa cum laude after only three years. She worked on relativistic spin-orbit coupling and superconductivity in different nanomaterials. In 2013, Jelena's PhD thesis earned her the Swiss Physical Society Award for outstanding research in the field of condensed matter physics, endowed by IBM. After completing her dissertation, she received a scholarship from Harvard University (Cambridge, USA) to continue doing theoretical research in quantum physics of condensed matter there.

Jelena Klinovaja is happy at the University of Basel and enjoys the close collaboration with colleagues, who deal with theoretical questions or their experimental implemenation.

### Back to Basel

For the next step in her career, an assistant professorship, Jelena had three options to choose from: University of Chicago, EPF Lausanne, and the University of Basel. "For me, a decisive factor was the excellent cooperation between theoretical research in condensed matter and outstanding experimental groups that Basel had to offer," the young researcher said of her decision to return to Basel, to the Department of Physics as a tenure-track assistant professor in 2014.

Thanks to an ERC Starting Grant which she received in 2017, her involvement in the NCCR QSIT, and funds from the SNSF, Jelena has been able to put together a notable international team consisting of two PhD students and five postdocs. In close cooperation with the group of Daniel Loss, Jelena and her colleagues are working on topics that they hope will contribute to the development of a quantum computer. Their goal is to create memory units (Qubits) that are more resistant to external disturbances than other Qubit candidates. In pursuit of this goal, Jelena wrestles with theoretical predictions and calculations involving a wide range of model systems that make the work of experimental physicists more likely to succeed.

### Success built on theoretical considerations

One possibility for more stable memory units involves a kind of exotic particle known as a Majorana fermion. Theoretically predicted over 70 years ago by the Italian physicist Ettore Majorana, these are particles with highly peculiar properties that make them promising candidates for a solution known as topological Qubits. However, even proving the existence of Majorana particles is difficult, and something of a lottery to begin with, as Jelena explains. Nevertheless, theoretical considerations and predictions

about which materials to use in which circumstances can improve the odds of finding the particles. For example, thanks to the joint efforts of Jelena Klinivaja's and Loss's teams, a group led by Professor Ernst Meyer (Department of Physics, University of Basel) succeeded in devising experimental conditions in which they were able to create, observe and image Majorana fermions at the extremities of nanowires that consist of individual iron atoms.

This is precisely the kind of synergy between theory and experiment that motivated Jelena to return to Basel in the first place, and the satisfaction it gives her is plain to see. "We have outstanding experimental physicists here in the department, whom we can support with our theoretical deliberations. I am very happy to be working in such a stimulating environment," she remarks.

**Building a network**

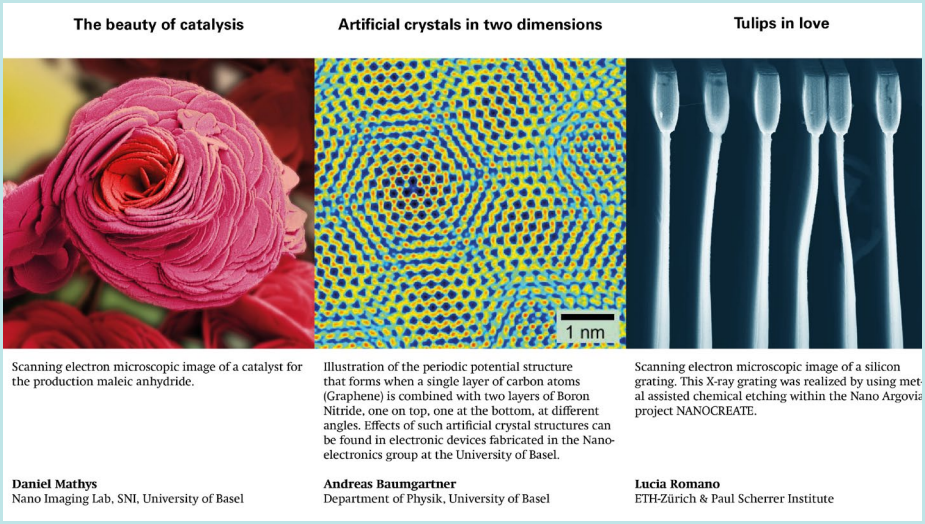
In order to have an overview of the topics the various groups are working on and to encourage discussion, Jelena organizes a weekly lunchtime seminar in which PhD students and postdocs have the opportunity to report on their research. "It is important for me as a junior member of the department to make contacts and build a network. We can learn from each other in-house in a way that would otherwise only be possible at conferences," she explains.

This is also why Jelena Klinovaja has been a member of the SNI for two years without having taken part in a project. That said, it is only a matter of time – her theoretical research revolves around highly topical problems that must be solved along the way to a quantum computer, and are perfectly suited to projects at the SNI PhD School.

# Nano Image Award

We would like to congratulate Daniel Mathys, Andreas Baumgartner and Lucia Romana on winning the Nano Image Award and to thank all those who took part with their breathtaking images from the nano and micro world.

https://nanoscience.ch/de/media-2/bilder/nano-image-award/




# antelope - the career program offered by the University of Basel for female reseachers

Female doctoral students and postdoctoral researchers can apply for the successful career program until 13 January 2019.

For more information, please visit: https://www.unibas.ch/en/Forschung/Graduate-Center/antelope-Programme0.html

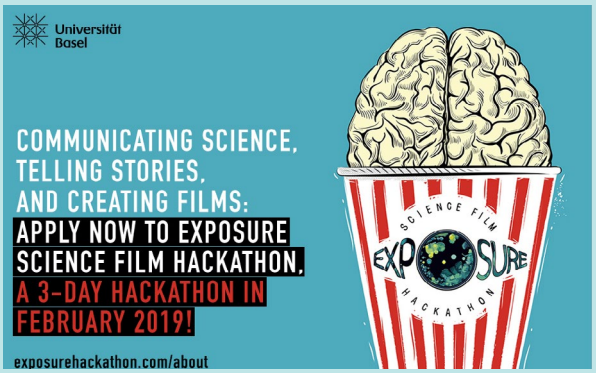
# SNSF Scientific Image Competition

The Swiss National Science Foundation (SNSF) has announced a competition for scientific images and videos.

The submission deadline is 31 January 2019.

For more information, please visit:
http://www.snf.ch/en/funding/science-communication/image-competition/Pages/default.aspx

# The Science Film Exposure Hackathon is coming to Basel




An event on 1–3 February will give people a chance to participate in the Science Film Exposure Hackathon – as a scientist, a filmmaker or a "Black Box".

The deadline for applications is 15 December 2018.

Further information on this opportunity to present science in a creative manner is available at:
http://www.exposurehackathon.com

# Events

## Nanotechnology provides diverse approaches to problem-solving

On 14 November 2018, a Nano-Tech Apéro was held at the premises of DSM in Kaiseraugst. An audience of around 50 interested individuals took the opportunity to learn about applied research supported by the Swiss Nanoscience Institute (SNI) as part of the Nano Argovia program and to network with participating researchers and industry representatives.

Companies from a wide range of industries hope to improve their products and processes with the help of applied nanotechnology. With this in mind, the Nano Argovia program was launched 13 years ago by the Swiss Nanoscience Institute (SNI). Since its establishment, the program has been responsible for 70 applied nanotechnology research projects, as explained by SNI Director Professor Christian Schönenberger in his talk.

**A steady stream of new projects**

New questions and lines of research are incorporated into the program on an annual basis, and the SNI organizes a Nano-Tech Apéro once or twice a year to provide an update and encourage communication between successive project partners from industry and academia. At the event in Kaiseraugst on 14 November 2018, Dr. Andri Vital, project leader of the Hightech Aargau program, reaffirmed the significance of nanotechnology for the Canton of Aargau, as well as the growing contribution of high-tech industry to the value chain.

**A varied mix of successful partnerships**

The focus then shifted to successful research projects in a series of talks by the respective scientists from the University of Applied Sciences Northwestern Switzerland (FHNW), the CSEM in Muttenz, and the University of Basel.

For example, Dr. Joachim Köser (FHNW Muttenz) explained how, in collaboration with DSM, he has managed to reduce the adhesion of bacteria to surfaces using nanostructures. Further studies will be necessary in order to give the surfaces additional antibacterial properties. Dr. Tim Grüne (PSI) described how electron-beam diffraction can be used in an industrial context to determine the three-dimensional structure of tiny crystals that are too small for X-ray structure analysis. He recently published an SNI-funded Nano Argovia study on this topic in cooperation with the companies Dectris AG and Crystallise! AG. The publication received an extremely positive media response within the scientific community.

Dr. Benjamin Gallinet (CSEM Muttenz) spoke about a successful collaboration with Rolic Technologies Ltd. that aims to develop a plasmonic phase retarder for displays in sensor technology or imaging applications. The scientific talks were rounded off by Thomas Stohler, who is in the process of founding a start-up based on the results of various projects from the Nano Argovia program and the SNI PhD School. He plans to provide a fully automated sample preparation platform for cryo-electron microscopy and single-cell analysis. The individual components of the device have been developed over the


The mixture of lectures and dicussions at the various posters is attractive for participants of the Nano-Tech Apéro.

last few years by scientists in the group of Dr. Thomas Braun (C-CINA, University of Basel) and could now help other teams of scientists with their research.

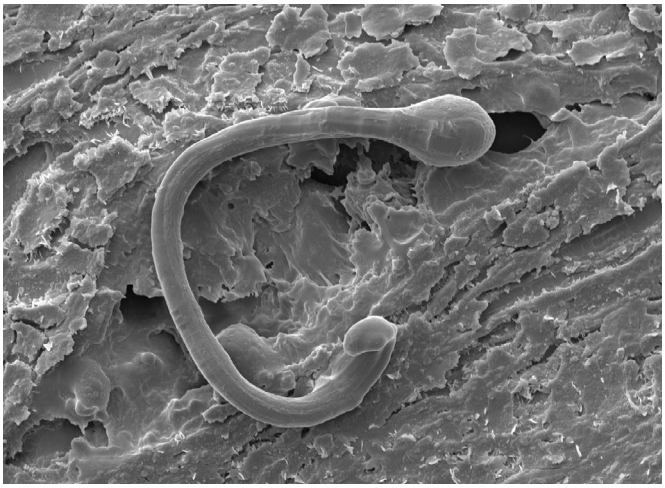
During the break and at the end of the event, the guests had an opportunity to discuss posters with the leaders of other Nano Argovia projects and to learn more about the various lines of applied research. “Lots of useful discussions took place, and new contacts were established,” says Dr. Michèle Wegmann (SNI), who organized the event for precisely this purpose and thanked DSM for being a perfect host.

# Joining forces to tackle pests

For many years, the Nano Imaging Lab (NI Lab) at Basel University’s Swiss Nanoscience Institute has been involved in research projects supporting sustainable viticulture. On 5 November 2018, Dr. Markus Dürrenberger, head of the NI Lab, attended a meeting of viticulture experts at the Ebenrain Center for Agriculture, Nature, and Food in Sissach. The purpose of the meeting was to exchange ideas about various Interreg projects and to establish links between the Swiss partners in a range of projects established on a trinational basis. All project partners want to tackle the greater spread of pests – due to climate change and globalization – by cultivating resistant plants and minimizing the use of pesticides and insecticides.

**Detailed images provide new insights**

The Nano Imaging Lab (NI Lab) has been working closely with the Staatliches Weinbauinstitut (state viticultural institute) in Freiburg, Germany, for many years and is involved in the project Vitifutur and the planned follow-up project BoVitis. For example, electron microscope images obtained by the NI Lab provide information about when grapes become infected with the microfungus Botrytis. At the end of the ripening period, cracks form in the waxy layer covering the grapes and therefore allow infections to develop.



When microscopic cracks form in the waxy layer of the grapes the microfungus can infect the grapes. (Image: Nano Imaging Lab , Swiss Nanoscience Institute University of Basel)

As well as discussing scientific efforts to investigate infections, the participants in this exchange of expertise also addressed the cultivation of resistant plant types that require far less fungicide than conventional vines. Preserving the infection resistance of these fungi-resistant (“Piwi”) wines and their acceptance among customers were also on the agenda for this first meeting between the Swiss partners in the Interreg projects Vitifutur, VitiMeteo, AgroForm, InvaProtect, and BoVitis and the viticulture commissioners of the Cantons of Basel Landschaft and Aargau.

**Exchange is important**

“It’s important that we establish networks in the region in order to tackle these challenges together,” says Dr. Markus Dürrenberger of the Nano Imaging Lab at the University of Basel. “At this first meeting, we discovered that our projects complement one another perfectly, but that we know far too little about each other.”

The participants from Switzerland and from the state viticulture institute in Freiburg, Germany, now have a much clearer picture of the various activities, which range from scientific research to providing specific ad-

vice to winegrowers. They are planning to set up a network involving all of the Swiss partners in the Interreg projects and to improve the exchange of results so that the region's wine-growing industry is equipped to face the challenges of the future.

**Websites of the various Interreg projects:**

Vitifutur: http://www.vitifutur.net

Vitimeteo: http://www.vitimeteo.de

Agroform: https://www.baselland.ch/politik-und-behorden/direktionen/volkswirtschafts-und-gesundheitsdirektion/landw-zentrum-ebenrain/landwirtschaft/spezialkulturen/rebbau/projekt-agroform

InvaProtect: https://www.isip.de/isip/servlet/isip-de/meta/invaprotect-99016

Partners of different Interreg projects plan to set up a network (Image: Staatliches Weinbauinstitut, Freiburg, Germany).

# A major step completed

In October, sixteen nanosciences students celebrated the successful completion of their bachelor's degrees.

In their initial years here at the University of Basel, the young graduates acquired a broad foundation in the natural sciences, in preparation to further pursue their individual interests in a master's degree. To this end, they will write two project papers in molecular biology, chemistry or physics, before concluding the master's program with an in-depth dissertation on a topic of particular interest to them.

For one of their projects, many students make use of the SNI's Argovia Travel Grant, which provides funding for a university placement abroad, enabling them to benefit from new experiences.

Sixteen of the twenty-one graduates of the Bachelor's Program in Nanosciences attended the degree ceremony in October (Image: University of Basel).

# New brochure on the nanosciences degree

Who is the nanosciences degree aimed at? How is the program structured and what topics are taught?

Questions like these are answered in the SNI's new brochure on the nanosciences degree course. We will be happy to provide you with a few copies if you know any young people who might be interested in this exciting, challenging and interdisciplinary degree program at the University of Basel.

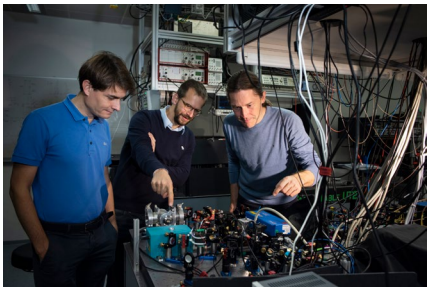
https://nanoscience.ch/wp-content/uploads/sites/8/2018/11/nanostudium_final_all_29_10.pdf

# Press releases and news from the SNI network

**Nature, 21 November 2018. Structural superlubricity and ultralow friction across the length scales**
Structural superlubricity, a state of ultralow friction and wear between crystalline surfaces, is a fundamental phenomenon in modern tribology that defines a new approach to lubrication. Early measurements involved nanometre-scale contacts between layered materials, but recent experimental advances have extended its applicability to the micrometre scale. This is an important step towards practical utilization of structural superlubricity in future technological applications, such as durable nano- and micro-electromechanical devices, hard drives, mobile frictionless connectors, and mechanical bearings operating under extreme conditions. Here we provide an overview of the field, including its birth and main achievements, the current state of the art and the challenges to fulfilling its potential.
https://www.nature.com/articles/s41586-018-0704-z.epdf?author_access_token=6jf9P7JcTp5ob7A1tRcxUNRgN0jAjWel9jnR3ZoTv0No3wcZG-tA_eEokrj9aNM8_4bDcxOvIYkcs2gkKoYzHxIPHphqN0aSFRF7mmBX3VKVRntQbFpi2dmNJyIIN-K9BoH0fuqWs96iyD99cEULv8g%3D%3D

**Swiss Nanoscience Institute, 15 November 2018. Nanotechnology provides diverse approaches to problem-solving**
On 14 November 2018, the premises of DSM in Kaiseraugst provided the venue for an information event about the Nano Argovia program of the Swiss Nanoscience Institute (SNI). At this Nano-Tech Apéro, an audience of around 50 individuals took the opportunity to learn about applied nanotechnology research supported by the SNI and to network with participating researchers and industry representatives.

**University of Basel, 29 Oktober 2018. Quantum Technologies Flagship: Basel physicists participate in three research consortia**
Today, the European Commission launched its flagship initiative on quantum technologies. Three research groups from the Department of Physics at the University of Basel are involved. The aim of the 1 billion euro research and technology funding program is to develop radically new and powerful quantum technologies by exploiting various quantum effects.



For complete media releases please visit:
https://nanoscience.ch/en/media/recent-press-releases-2/

# Your feedback is important!

Please send ideas, feedback and material for “SNI update” to Christel Möller (c.moeller@unibas.ch).
We are looking forward to your input.