University of Basel

Swiss Nanoscience Institute

SNI SWISS NANOSCIENCE INSTITUTE

EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

SNI INSight

Showcasing research and activities at the Swiss Nanoscience Institute

December 2021

Artificial enzymes

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Forgotten data

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Translations and proof-reading: S. Regan and team (UNIWORKS, Erlangen, Germany)
Images: C. Möller and sources as indicated

Editorial

Dear colleagues and interested parties,

The second year of COVID-19's reign over our world is nearing its end. During that time, we have become accustomed to many things and even learned to embrace the silver linings. Working from home can be more relaxed and productive, and some meetings are more efficient when held over Zoom. Thanks to the vaccine, we had also been able to reopen a great many doors. We could gather again for meetings, greet one another face-to-face in the halls and hold in-person seminars for students in lecture halls.

We were even able to hold SNI network events in the past few months. What a pleasure it was to see so many new and familiar faces at the Annual Event in Lenzerheide and the Nano Tech Apéro in Egerkingen, among others. Our Outreach and Study Coordination teams were finally able to visit schools and trade fairs to share information on the nanosciences and generate interest in the nanosciences program among prospective students. I was particularly delighted that we were able to hold a party for our master's graduates. It is always lovely to see our young graduates again in this festive setting, where we have the opportunity to discuss and reflect on the diverse and extraordinary theses they have submitted. Most have now begun their professional careers, are mid-way through a doctorate or have put their knowledge to the test at a diverse array of companies.

Of course, even amid joyful events, there are sometimes moments of sorrow. This past month, Peter Reimann, a long-time employee of the Department of Physics and member of the SNI, passed away unexpectedly. He not only inspired us with his research, but he was also possessed of an enthusiastic commitment to public relations and helped make science and research accessible to a great many people.

When it comes to public relations, video is becoming an ever more effective medium to engage audiences with the subjects we study in the academic community. When he is not busy with his research, Simone Pengue, a doctoral researcher in the team supervised by Argovia Professor Roderick Lim, explores the potential of this medium. These efforts have paid dividends, and his film about forgotten data received the Prix Média Newcomer award. We explore his motivation for making the film in this issue of SNI INSight.

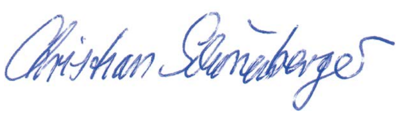
The first part of this issue of SNI INSight is devoted entirely to enzymes – not the ones we find in the natural world, but the artificial enzymes promising to unlock new avenues for molecular synthesis studied by the research group under Thomas Ward.

The new scanning transmission electron microscope, which is now being used to carry out different kinds of analyses in the Nano Imaging Lab, also promises to deliver exciting new insights. The SNI not only played a pivotal role in the purchase of this microscope; it was also one of the main sponsors of a scanning electron microscope purchased for the Swiss Science Center Technorama in Winterthur. We are currently working together with the Technorama to develop a program to spotlight the new device.

For this issue, we also interviewed Heidi and Patrick Potts, two alumni of the nanosciences program, who, after studying and working in different institutions around the world, have now found themselves back in Basel. The pair began their training together and then embarked upon different career paths. These two scientists are the perfect example of how a bachelor's in the nanosciences can make anything possible.

We hope you enjoy this and our other stories from the SNI. I wish you a peaceful and relaxed holiday season and a great start to a healthy and successful 2022!

Warmest regards,



Professor Christian Schönenberger, SNI Director

Designed on the computer, produced in cells

Artificial enzymes open up completely new possibilities

Chemical reactions accelerated by a catalyst play a fundamental role in our lives. Professor Thomas Ward, who heads the NCCR Molecular Systems Engineering and has been an active SNI member for many years, leads a team that combines different types of catalysis. The researchers' goal is to find new synthetic pathways that ensure effective, safe production of a wide variety of compounds, both inside and outside cells, that can also be applied in diagnostics and therapy.

Nobel Prize for specific type of catalysis

This year, the Nobel Prize in Chemistry went to the two professors Benjamin List and David W.C. MacMillan. Both focus their research on catalysis – chemical reactions that are accelerated by a catalyst. The catalyst enables and accelerates the reactions, but is itself not consumed.

Catalysis plays a major role in many areas of our lives. All living organisms depend on catalytic processes in order to survive with as little energy input as possible. Numerous chemical syntheses in industrial processes are also only possible and economical thanks to catalysts.

The two researchers received the 2021 Nobel Prize for the development of organocatalysis, a process in which relatively simple organic compounds without metals are used as catalysts.

Combined form of catalysis

In the SNI network, the team under long-time SNI member Professor Thomas Ward of the University of Basel's Department of Chemistry is working on catalytic conversions.

His approach is based on combining two types of catalysis (see box page 7) and producing catalysts with the advantages of both natural enzymes and catalytic metal complexes. To do this, Ward's team integrates metal complexes into natural proteins. The protein acts as a host and creates a propitious environment that enables a catalytic transformation to convert substrates into products with minimal energy input.

The resulting hybrid catalysts ideally display novel properties and are characterized by high activity and selectivity. Importantly, they are fully compatible with a cellular environment, including natural enzymes. Accordingly, artificial enzymes can be integrated into new-to-nature metabolic pathways to produce high added-value products within a living cell, as demonstrated by Ward's team at the NCCR Molecular Systems Engineering.

Optimized, highly complex compounds

While the process of integrating a metal complex into a protein may sound simple to a layperson, it is anything but. Natural proteins exhibit highly complex architectures, and are made up of amino acid chains that fold according to a specific blueprint. Their three-dimensional structure affects the functionality of proteins – it is only when the proteins are folded correctly that they can fulfill their task as a biocatalyst (enzyme) in cells.

In nature, enzymes have evolved in living organisms over millions of years. They are elementary components of a well-rehearsed process, ensuring that the multitude of chemical processes in cells run smoothly. Producing new artificial enzymes in the laboratory that are superior to natural ones in terms of their properties and able to catalyze new-to-nature reactions requires a great deal of know-how, as well as a portion of luck.

Effective solution

The Ward team has succeeded in producing such artificial enzymes, with characteristics found neither in the individual components, nor in nature at large.

The researchers often rely on what is known as biotin-streptavidin technology for this purpose. Streptavidin is a bacterial protein that displays an exceptionally strong binding affinity to the vitamin biotin. Linking a metal complex with (modest) catalytic activity to biotin ensures that in the presence of streptavidin the metal is incorporated into streptavidin, thereby creating an artificial metalloenzyme.

Thomas Ward and his group are developing artificial metalloenzymes that have new properties. (Image: M. Wegmann, SNI)

A versatile artificial metalloenzyme

Almost ten years ago, scientists from the Ward lab succeeded in creating an artificial metalloenzyme that catalyzes one of the most challenging reactions in chemistry: the functionalization of an inert C–H bond. To this end, they integrated a catalytic rhodium metal complex into the streptavidin host.

This new combination initially accelerated the targeted chemical reaction with only a low yield. Guided by a detailed understanding of the catalytic mechanism, two close-lying amino acid residues of streptavidin were mutated. This led to a hundredfold acceleration of the reaction, as these mutations enabled a critical deprotonation step, essential for the reaction to proceed smoothly.

Host structure is crucial

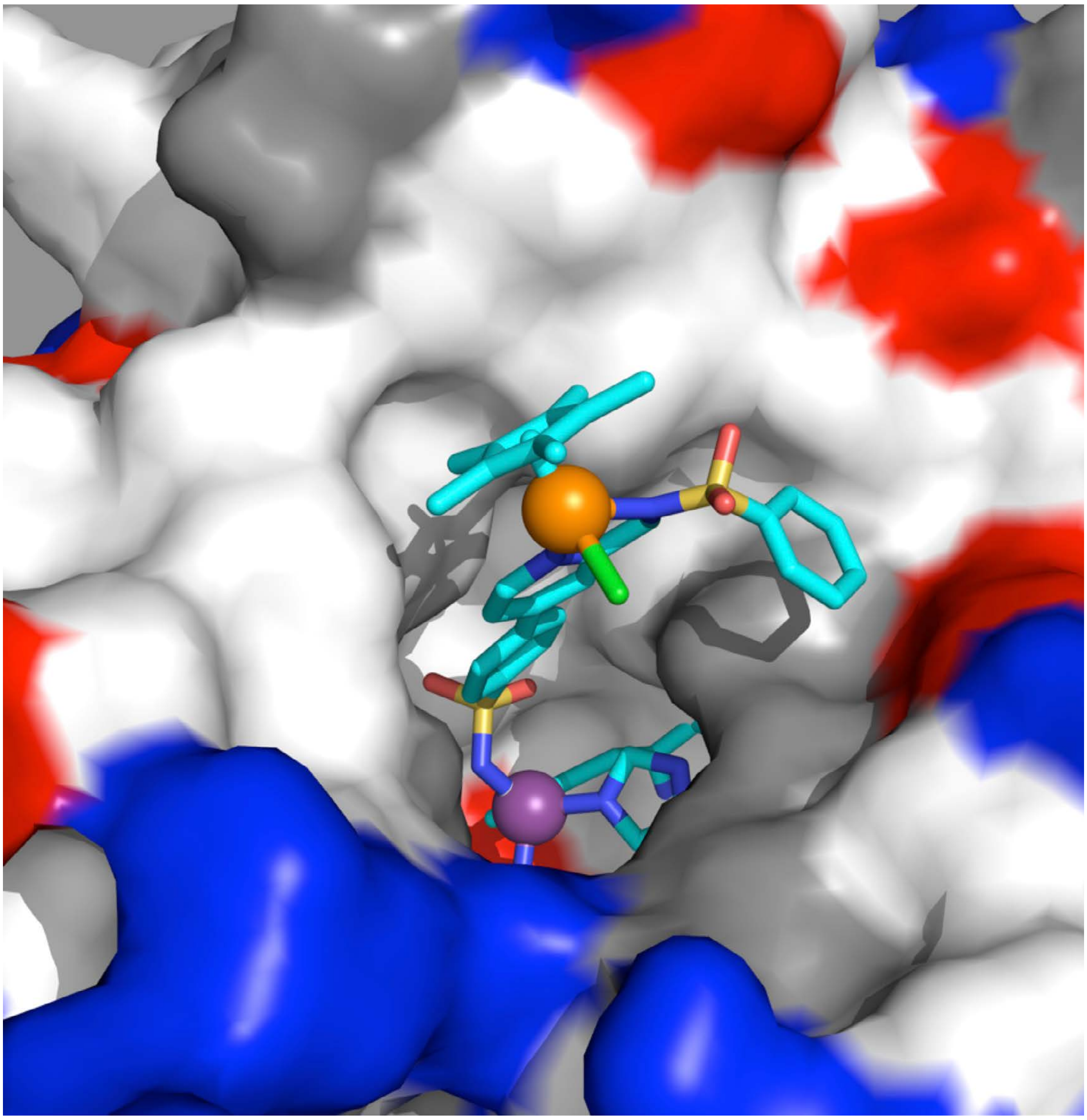
As part of an SNI PhD school project, the Ward team has developed an artificial hydrogenase that supports the splitting of water into its components oxygen and hydrogen. “Hydrogenases are of great interest because they are suitable for the production of hydrogen as an energy storage medium,” explains Thomas Ward.

In the project, former SNI PhD student Dr. Sascha Keller used a cobalt metal complex that he integrated into different variants of the streptavidin complex. The work showed that the streptavidin amino acids located close to the incorporated metal complex have a major influence on the hydrolytic activity of the artificial enzyme. Presumably, protons are efficiently shuttled via these amino acids during the catalytic reaction.

Sources:

Science (2012):
Biotinylated Rh(III) Complexes in Engineered Streptavidin for Accelerated Asymmetric C-H Activation
doi: 10.1126/science.1226132)

Helvetica Chimica Acta 2018, 101 (4):
Photo-Driven Hydrogen Evolution by an Artificial Hydrogenase Utilizing the Biotin-Streptavidin Technology
https://onlinelibrary.wiley.com/doi/10.1002/hlca.201800036



High-resolution X-ray structure of a metal catalyst. (Image: Department of Chemistry, University of Basel)

Sources:

DrEAM_ERC:
https://erc.europa.eu/projects-figures/erc-funded-projects/

Nature (2016):
Directed evolution of artificial metalloenzymes for in vivo metathesis
doi:10.1038/nature19114

Living "factories" also work
Meanwhile, researchers have also succeeded in producing similar artificial metalloenzymes in living cells (*in vivo*). This work is supported primarily by an ERC advanced grant (DrEAM_ERC).

Before the artificial enzymes can be used in a cell, researchers must ensure that all components can be taken up by the cells. In addition, it is important to know which compartments of a cell offer suitable conditions for the reaction to be catalyzed.

In the development of a metalloenzyme that catalyzes the formation of carbon-carbon double bonds (i.e. alkene metathesis), this was the space between the inner membrane of the cytoplasm and the outer membrane in gram negative bacteria. The researchers were able to create conditions that met the requirements so that the artificial metalloenzyme could be assembled by the bacteria in this reaction compartment, known as the periplasm.

They used specially developed strains of the intestinal bacterium *Escherichia coli*, which produce streptavidin in the periplasm, to produce the targeted artificial metalloenzyme Biot-Ru-SAV. The enzyme contains a catalytic ruthenium metal complex. It accelerates the desired chemical reaction with a ring-shaped molecule as the product, which the researchers can easily detect thanks to its fluorescence.

Catalysts – Effective chemical reactions

Chemists distinguish between heterogeneous, homogeneous and enzymatic catalysis.

In **heterogeneous catalysis**, the substrate and catalyst are in different physical states. This group includes, for example, exhaust gas catalysts, in which the solid metals platinum and rhodium catalyze the conversion of the gases carbon monoxide and nitrogen monoxide to carbon dioxide and nitrogen.

In **homogeneous catalysts**, the substrate and catalyst are in the same physical state. An example of this is the lead chamber process, which was already known in the Middle Ages and was used to produce sulfuric acid. In a reaction optimized in the 19th century, nitrogen oxides are used as catalysts that oxidize sulfur dioxide.

In numerous other homogeneous catalytic chemical reactions, metal complexes are used as catalysts.

Enzymatic catalysis uses special natural proteins (enzymes) as catalysts. These naturally occurring enzymes have evolved over millions of years and make life as we know it possible. Roughly four thousand enzymes are used by the human body to maintain its activities. In many cases, they work far more specifically and effectively than synthetic, organometallic catalysts.

Chemically speaking, enzymes are macromolecules consisting of a large number of amino acids, and often have a metal ion in the active site. By contrast, the catalysts used in synthetic chemistry are usually much less complex chemical compounds.

By combining chemical and natural building blocks, it is possible to produce artificial enzymes that do not occur in nature but combine the benefits of both enzymes and homogeneous catalysts. Ideally, they possess properties not found in the individual components. Perhaps the most appealing feature of artificial metalloenzymes is the fact that their catalytic activity can be optimized by introducing mutations in the gene encoding the host protein. In a Darwinian spirit, it is thereby possible to apply evolutionary pressure to “force” an artificial metalloenzyme to adapt to the stringent conditions imposed by the experiment.

Optimized outcome

The researchers were able to further increase the yield of the artificial enzyme and the end product by a technique known as directed evolution. Similar to natural selection, selection pressure through the composition of the culture medium ensures that only bacterial strains containing the artificial enzyme can survive. To this end, the researchers developed a simple and robust screening method allowing them to test thousands of bacterial strains and select the best producers.

“With the system we applied, we can develop entirely new synthetic pathways. We can catalyze new individual reactions, but also entire reaction cascades, turning cells into molecular factories,” remarked Thomas Ward of this approach.

Active in mammalian cells

As well as using the artificial metalloenzymes in bacterial strains, the researchers are also able to initiate a reaction cascade in mammalian cells.

For example, they developed a ruthenium metalloenzyme that can enter a mammalian cell. Inside the cell, the artificial enzyme catalyzes the production of a specific thyroid hormone. This activates a synthetic gene switch that leads to the production of the enzyme luciferase. Luciferase catalyzes a chemical conversion that is accompanied by the emission of light – which the researchers can follow and quantify microscopically.

“This finding highlights the potential to integrate artificial enzymes into mammalian cells, thus expanding the available toolbox to reprogram cells for therapeutic purposes,” Thomas Ward explained.

New SNI project planned

In addition to new synthetic routes, the artificial metalloenzymes also offer opportunities in diagnostics and therapy.

As part of a new project in the SNI PhD School, the Ward team, in collaboration with Professor Melpomeni Fani of the University Hospital, will investigate how metal complexes can be specifically incorporated into receptor proteins found primarily on the cell surface of cancer cells. Linking a highly specific inhibitor of such receptor proteins to the metal catalyst allows the latter to accumulate where its therapeutic action is required: in the proximity of the tumor.

The purpose of these artificial metalloenzymes is to catalyze the uncaging of a chemotherapeutic drug. The active ingredient is not toxic to cells as long as it is caged. The uncaging of the active drug only occurs in the presence of the artificial metalloenzyme, which is mostly present on the surface of cancer cells. This catalytic strategy will thus minimize the undesirable side-effects of many chemotherapeutic drugs.

In collaboration with Professor Fani, researchers will test this innovative strategy both for diagnostic and therapeutic purposes for various types of cancers.

Numerous possible applications

Thus far, the Ward group has engineered fourteen catalytic transformations with artificial metalloenzymes. Importantly, no natural enzyme is known for any of these transformations.

Sources and further information:

Nat. Commun., 2018, 9, 1943:
A Cell-Penetrating Artificial Metalloenzyme Regulates a Gene Switch in a Designer Mammalian Cell
https://doi.org/10.1038/s41467-018-04440-0

"The prospect of combining both artificial and natural enzymes in a cell opens fascinating perspectives on the development of cellular factories for the production of biofuels and high added-value chemicals. We can use artificial metalloenzymes not only to produce new chemicals with high added value, but also to support the development of diagnostic methods and effective therapies."

Professor Thomas Ward, Department of Chemistry and Director NCCR Molecular Systems Engineering, University of Basel

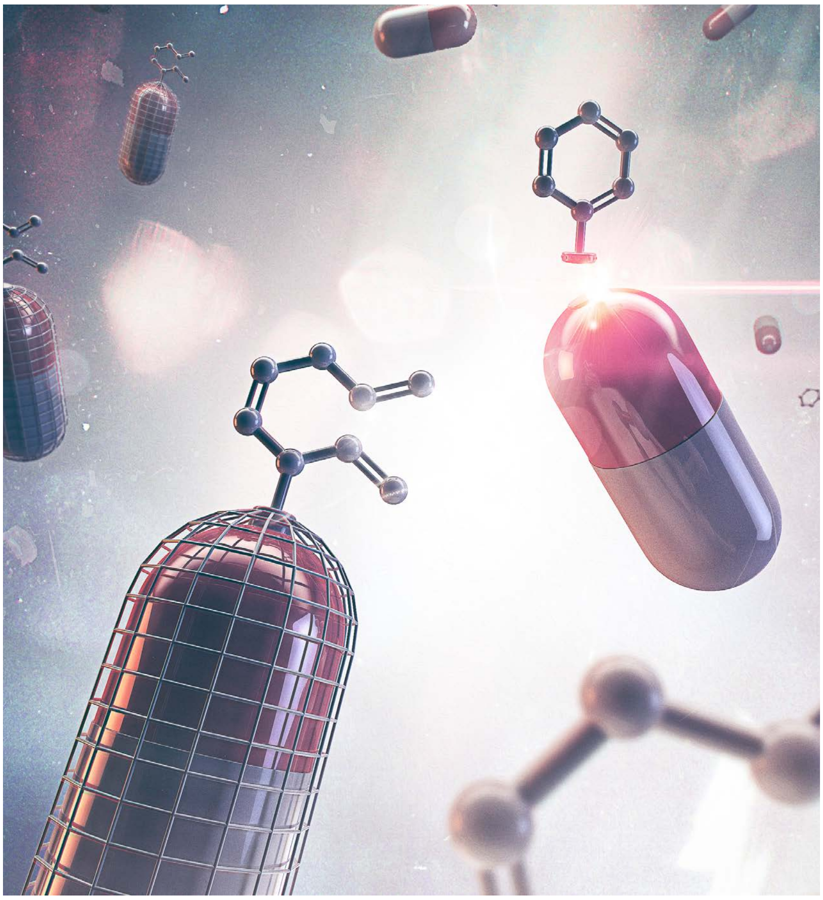


Illustration for the title page (J. Am. Chem. Soc 2019) showing the concept of releasing a caged drug. (Image: Department of Chemistry, University of Basel)

Forgotten data
A dry subject presented in an exciting way awarded the Prix Média

Simone Pengue has won the 2021 "Prix Média Newcomer" from the Swiss Academies of Arts and Sciences for his documentary on lost data. Simone is a PhD student in the research group of Argovia professor Roderick Lim. In addition to his own research, he is passionate about explaining science in a vivid and entertaining way. In this interview, he explains how the idea developed resulting in an entertaining and interesting film, and how he is committed to science communication alongside his demanding work as a PhD student.

A physicist fascinated by proteins

Simone Pengue's main job is working on his doctoral thesis on the dynamics of proteins in the group of Argovia professor Roderick Lim. The young physicist, who completed his bachelor's degree in Como and his master's in Fribourg, initially had his sights set on other topics and first took a slight detour during his doctorate.

After completing his master's degree, he joined Professor Philipp Treutlein's group at the Department of Physics in 2017 to do his doctorate in atomic physics. Quite quickly, however, he realized that this subject area was not the right one for him. He switched to biophysics in Roderick Lim's group and has been working on the complex world of proteins ever since. "Although I hadn't worked in the field before, I was fascinated. And Rod trusted me to learn the ropes quickly," Simone comments on his move.

Simone Pengue has won the "Prix Média Newcomer" 2021 awarded by the Swiss Academies of Arts and Sciences.

Interest in science journalism

It was also during this time that he became interested in science journalism. Philipp Treutlein had advised him to do what came naturally to him. For Simone, that has always been talking about his work and reporting on research. So, he asked a friend who works at Keystone-sda for contacts of science journalists. He also joined the Swiss Club for Science Journalism and began to build a small network. Since then, he has been writing articles on scientific topics for a broad audience a few times a year – among others, for the communication agency "catta". Its founder also brought the call for entries for the Prix Média Newcomer 2021 to his attention.

Simone had already participated in the workshop "Storytelling & Storyboarding in Science" at the Zurich Film Festival (October 2020), organized by the Swiss Academy of Sciences and Swiss Universities with the Locarno Film Festival as a partner. Even before Simone got the suggestion to participate in the film competition, he had a film idea in his head.

Fate of scientific data

At the beginning of his PhD at the Biozentrum, he had been told that all data should be backed up on a server. However, the questions of what would happen to the data, who would have access to it, and how it would be reused had not been fully resolved for him.

The question became quite topical for Simone when he observed patterns in other physical parameters (fluorophore lifetime) during measurements of protein dynamics. He himself and his lab colleagues had no scientific question for such data and therefore no interest or time to pursue this further.

“I thought to myself that the observations and data, however, could be quite relevant to other researchers,” Simone recalls, “but I didn’t know how to make them available to other groups.” The idea then developed to make a film about such data and, more generally, to explore the question of what happens to big data in science, whether and how it can be shared, and what points need to be considered.

Selected for the finals

In April, Simone submitted a brief description of his film, “FORGOTTEN DATA: The Leftovers of Science.” He received positive feedback that his film was one of the two projects funded with 3,000 Swiss francs and that he could start with the detailed planning.

For Simone, the good news marked the beginning of a stressful period. Together with his brother Lorenzo, who took over the technical part, Simone planned, interviewed, cut, edited and translated the 38-minute documentary – and all this alongside his work as a doctoral student, which continued as usual during this time. The only time he took off was five days for the interviews with various experts. All other activities for the film happened in the evenings and at night, after he had spent the day writing a manuscript for a scientific publication as part of his doctoral thesis.

Valuable stimulus for discussion

It was worth it! Simone and his brother have won the Prix Média Newcomer and received prize money of 4,000 Swiss francs. Their film represents a valuable contribution to a current, important topic and in some circles has further stimulated discussion about the fate of scientific data.

“In general, scientific data should be publicly available, but it has become clear that there is no solution for all eventualities and that there are cases where publishing raw data causes problems,” Simone summarizes.

Simone works as a PhD student in the team of Argovia professor Roderick Lim at the Biozentrum of the University of Basel.

In the course of his research, he has found that there are big differences in the various disciplines when it comes to making data freely available. “While researchers in the field of high-energy physics, such as at CERN, share all data, the privacy of personal data plays a big role in medical studies,” he reports.

Asked if he will continue to explore the topic in more detail in the future, Simone replies, “I could well imagine organizing a conference together with bioethicists as a follow-up, where we discuss data accessibility in different scientific fields.”

The SNI team will follow this discussion and offers its warmest congratulations on this well-deserved award.

Further information:

Trailer of the videos:
https://www.youtube.com/watch?v=3LmA1NWMEuM

Documentary “Forgotten Data: The Leftovers of Science” (38 minutes):
https://youtu.be/cdgZAJYsLcM

Research group Roderick Lim:
https://www.biozentrum.unibas.ch/research/research-groups/research-groups-a-z/overview/unit/research-group-roderick-lim

Heidi and Patrick Potts
Everything began with nano

Heidi and Patrick Potts both began their careers as students of the nanosciences at the University of Basel. After finishing their doctoral dissertations in Lausanne and Geneva, respectively, and completing postdoctoral work in Sweden, they have returned to Basel. Heidi moved into the private sector and is very satisfied in her position as application scientist at Zurich Instruments. Patrick, as assistant professor in the Department of Physics, has also realized his dream of leading his own small research group. Both Heidi and Patrick appreciate the broad education they received during their degree program in the nanosciences as it helped them each to forge their own path – together.

Beginnings in Basel

Patrick Potts began his professional training in 2007, and Heidi Potts followed in 2008. Both had taken an interest in science back in high school, but neither had developed a passion for any specific subject area. That made the bachelor's program in the nanosciences an ideal fit because students only choose a specialization later in their studies.

After finishing her bachelor's degree, Heidi knew that this interdisciplinary approach was the right choice for her future career, so she went on to complete her master's in the nanosciences, as well. With the support of an Argovia Travel Grant, she set out for Toronto to work on her master's thesis, which ultimately earned her an award for best master's thesis in the nanosciences in 2014, the very first year the prize was presented. Her winning thesis focused on the topic of cutting-edge, ultra-thin silicon solar cells. She had already developed a fascination for applied research in the field of nanotechnology, and this early interest continued to accompany her as her career progressed.

After finishing his bachelor's, Patrick was not as certain about the subject he wished to pursue. He completed an internship in biochemistry in Japan. "I was interested in some of the topics in the field, but ultimately I decided against the interdisciplinary nanosciences master's program and switched to physics. For my master's thesis, I focused intensively on solid-state physics," he says.

Yet Patrick certainly does not regret the first few years he spent in the nanosciences program, and he believes he learned a lot of valuable information during his bachelor's studies in nanosciences that guided his personal development and continues to serve his career today. "In those first few years, I learned to speak the language of physicists, biologists and chemists. And during my time in the nanosciences program I learned a lot about various aspects of thermodynamics. Now, the focus of my research is quantum thermodynamics, and my fascination with the field has its roots in my undergraduate studies," he comments.

Dissertation in Romandy

After their respective master's programs, both scientists relocated to Southwestern Switzerland. Heidi completed her dissertation at the Swiss Federal Institute of Technology Lausanne in the research group supervised by Professor Anna Fontcuberta i Morral. There she studied the growth, crystal structure and transport phenomena of nanowires with novel physical properties, conducting her doctoral work in association with NCCR QSIT – Quantum Science and Technology.

Patrick began his doctoral dissertation in the field of theoretical mesoscopic physics at the University of Geneva in the research group supervised by Professor Markus Büttiger, who passed away soon after. With the aid of a Doc. Mobility Grant awarded by the Swiss National Science Foundation (SNSF), Patrick was able to secure a research stay in Montreal and finally completed his dissertation under Professor Christian Flindt.

Relocation to Sweden as postdocs

After Lausanne and Geneva, the young pair of scientists packed up and shipped out to Sweden – but they would not be making this journey alone. In the space between Heidi's private and public theses defenses, the two became parents to a baby girl.

"We assumed our postdoctoral positions in Lund on 1 January 2018, just four months after she was born," recalls Heidi. Sweden offers excellent working conditions for young

Heidi and Patrick Potts began their careers with a Bachelor›s in Nanosciences and then each found their own individual path – together.

Further information:

Zurich Instruments:
www.zhinst.com

Research team Patrick Potts:
https://qtd.physik.unibas.ch/en/

Article on Heidi Potts's award-winning master's thesis:
https://nanoscience.ch/en/2014/04/28/preis-fuer-die-beste-masterarbeit-geht-an-heidi-potts/

Alumni video, Heidi among others talks about the nanosciences programm in Basel
https://youtu.be/tRGXZjU-gRxw

parents, but it initially proved challenging for Heidi and Patrick to accommodate both the demands of their careers and those of their new family. "It took a lot of flexibility on the part of our supervisors – and for us, too – but we managed well during those early days," says Patrick. "Once everything is sorted out, the conditions in Sweden are ideal for achieving a balance between family and work," he adds. For the Potts family – which would soon expand to include a second daughter – this family-friendly setting, along with an enjoyable work environment, great colleagues and growing circle of friends, filled the 3 ½ wonderful years they spent in Sweden with a host of happy memories.

Back to Switzerland

But old friends, family and their love of the mountains eventually beckoned their return to Switzerland, and the pair settled in Basel, where Heidi and Patrick had begun their studies so many years ago.

For Heidi, this move offered the ideal opportunity to move into the private sector, where she would be able to work in applied research in the field of testing and measurement systems. As for Patrick, he was presented with the unique chance to take on a position as assistant professor and establish his own small research group. He applied for an Eccellenza Professorial Fellowship at the SNSF, and after being awarded the position, began his research in the Department of Physics at the University of Basel in mid-April 2021. He now leads a team of two doctoral students and two postdocs. Together, the theoretical physicists study the thermodynamic effects of quantum systems.

"I am fascinated by the work being done at the interface between quantum physics and thermodynamics," he says. "It's a dream come true to head my own group and to have the chance to research things such as how to control, manipulate or use the flow of heat in small quantum systems." Patrick loves diving deep into a subject area, or in his words, becoming a "hyperspecialist" and collaborating with colleagues from his department.

Heidi was not drawn to the idea of remaining in academic research. She had always been interested in applied science, so she decided to use this opportunity to try and make the leap to the private sector. “The difficult part was finding out what kinds of jobs were a good match for my background and my interests,” she explains.

Early in this orientation phase, she stumbled upon a job offer from Zurich Instruments for a position as an application scientist. The position in the ad was not an exact fit for Heidi’s skills, but applying gave her a chance to introduce herself at the company. “They told me to be in touch again in November 2020, and following the interview process, they offered me a position as an application scientist quite quickly,” she says.

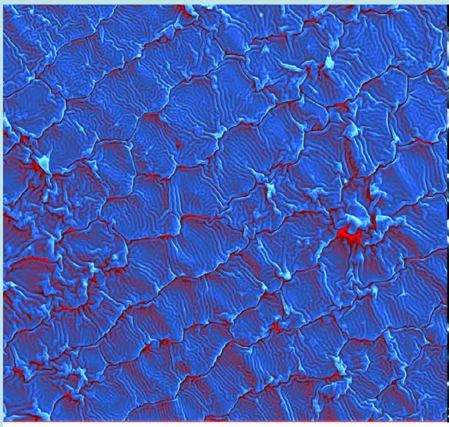
So, the Potts family has now returned to Switzerland. They are settled in nicely and are pleased to be closer to friends and family, and they have also scheduled time to care for their two daughters. Compared to Sweden, the longer working hours in Switzerland make it much harder to strike a balance between personal and professional responsibilities. But both Heidi and Patrick have reduced their work hours and found a way to make time for both their employers and their family.

Always a place for nanoscience

For these two young scientists, their shared path began in Basel with a bachelor’s in nanosciences. Both emphasize that this program had far more to offer than a broad scientific education. They learned to speak the language of numerous disciplines and gained an understanding of a vast array of research areas. The two came to appreciate the extraordinary sense of camaraderie shared between the students in the program and made lifelong friendships, which, since their return, they now have more time to cultivate.

If she had to choose all over again, Heidi Potts would always opt to study nanosciences. In her current position, where she has contact with customers from widely divergent fields, her broad education has served her well. But even Patrick Potts, who fell in love with physics after his bachelor’s, would choose nanosciences again, given the chance. “Not necessarily for my career,” he says. “It’s just extremely interesting to be able to explore and get to know so many different fields.”

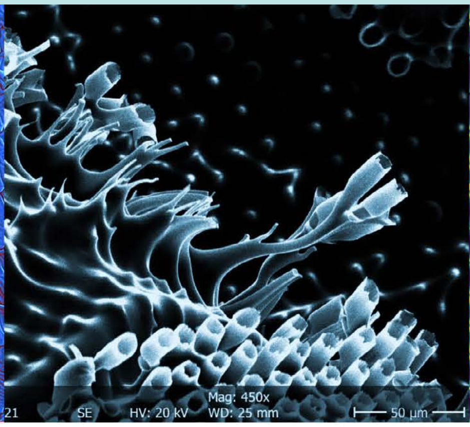
Winners of the Nano Image Awards 2021



Fragile worm skin

Scanning electron microscopy image of the skin (horny keratin scales) of slowworm (*Anguis fragilis*).

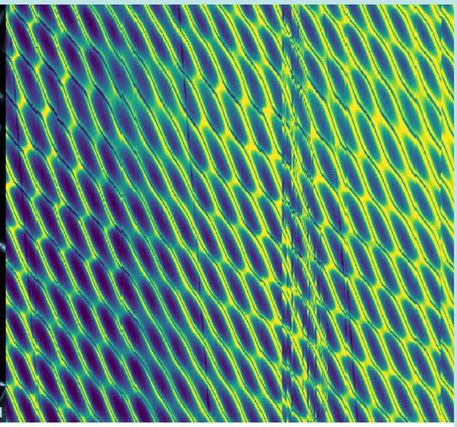
Massimo Trifone and Sina Saxer
NanoLab, University of Applied Sciences and Arts (FHNW)



Christmas candles

Scannning electron microscopy image of artifact structures on a hot-embossed polymer film.

Manuel Kraus
CSEM Center Muttenz



Poseseidon‘s net

Single electron resonances in a double-quantum dot measured by means of spectroscopy of a superconducting resonator.

Alessia Pally and Jann Ungerer
Department of Physics, University of Basel

Many thanks for your participation and congratulations to the winners!

In memory of Peter Reimann

Dr. Peter Reimann, a long-time employee of the Department of Physics and member of the SNI, passed away unexpectedly on 1 November 2021.

For over 37 years, Peter had been employed at the Department of Physics at the University of Basel, where he headed the Technology & Safety Group. He was an enthusiastic researcher and communicator. During his career, he not only contributed to the scientific successes of the department, but also shared his fascination for the natural sciences with broad audiences at public events. In 2006, he was awarded an honorary doctorate from the Faculty of Science for his extraordinary work.

For the SNI staff, Peter served as the point of contact for a wide variety of issues. He supported the SNI in numerous activities by bringing his expertise, enthusiasm and humor to bear and seeding inspiration through the ongoing contribution of original ideas.

We will remember him fondly as a kind and knowledgeable colleague. Our thoughts are with his family.

A brief description of Peter Reimann's professional achievements can be found in the SNI Annual Report 2015.

https://nanoscience.ch/wp-content/uploads/sites/8/2021/11/peter_reimann_en.pdf

Ready for action

New scanning transmission electron microscope in the Nano Imaging Lab

The staff of the SNI Nano Imaging Lab (NI Lab) have commissioned a new scanning transmission electron microscope (STEM), which is prized for its high resolution and magnification. Dr. Marcus Wyss is currently conducting the inaugural research projects using the device and is looking forward to taking on new tasks and challenges.

Marcus Wyss is the main contact person responsible for helping clients from diverse fields with their questions and applications related to the new scanning transmission electron microscope.

Regarding questions about the NI Lab or the new STEM, please feel free to contact:

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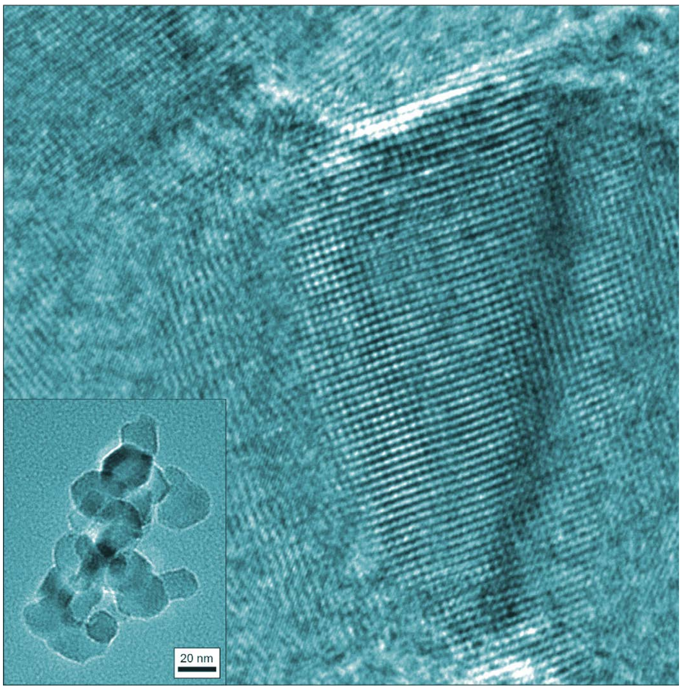
In fall of 2018, a survey of research groups at the University of Basel found that some groups were in dire need of a new scanning transmission electron microscope with improved resolution and analysis capabilities. After several minor hiccups and a few more substantial issues, this new device, manufactured by the company Jeol, now stands ready for operation in a specially redesigned room located in the basement of the Department of Pharmaceutical Sciences. The new microscope allows the NI Lab team to capture high-resolution images of nanostructures inside thin samples and perform material analyses.

Atomic resolution

The new TEM/STEM can take measurements in two different modes: The conventional or fixed beam mode employs a fixed beam of electrons, while rastered beam mode uses an extremely fine beam of electrons to scan the sample, pixel for pixel. The device is equipped with a so-called cold field emission gun, which enables it to produce high-resolution images.



The first TEM images Marcus Wyss produced were of TiO_2 nanoparticles. Even in fixed beam mode, the crystal structure of the particles in different orientations is visible; the resolution is even better in rastered beam mode.

Transmission electron microscopy

Transmission electron microscopy (TEM) is a technique in which electrons emitted from an electron source are transmitted through ultrathin sections of objects in order to capture images of the internal structures of these samples. Lens systems are used to focus the electrons so that they all strike the desired area of the sample roughly parallel to one another. The electrons are also accelerated. When the sample is illuminated, the emitted electrons either scatter, pass through the object or cause the sample to emit new electrons. Heavier atoms with higher atomic numbers and thicker sections of the object cause stronger scattering.

Various coils, which produce magnetic fields and function like lenses, control the electron beam as it passes through the object, and the electrons strike a detector on the other side. If many electrons are detected at a single point, that area will be brighter; fewer electrons produce darker areas. The result is a grayscale image showing highly detailed structures within the sample. A vacuum is maintained in the interior of the TEM to minimize disruptions to the electron beam.

Generally, a transmission electron microscope is either a fixed beam transmission electron microscope or a scanning transmission electron microscope. A conventional or fixed beam transmission electron microscope (CTEM) illuminates the object using a fixed beam of electrons. A scanning transmission electron microscope (STEM), on the other hand, uses a fine, focused beam of electrons to scan the sample, pixel for pixel, resulting in image resolution down to the level of the atom.

Researchers can use this new microscope to magnify objects up to one million times, thus rendering individual atoms visible. The microscope’s maximum resolution is 0.19 nanometers.

This excellent resolution allows researchers to view the crystal structure of samples, thereby revealing the arrangement of individual atoms. Researchers can use this information to conduct minute analyses of the interfaces in the substructures of nanowires, for instance. Moreover, the new STEM serves a broad range of applications in the study of diamond flaws and two-dimensional materials. Thanks to the energy-dispersive X-ray spectroscopy (EDX) system installed inside the microscope, researchers are not only able to generate images of their samples; they can also analyze specific chemical compositions at different points within the sample.

Full service

Services provided by the Nano Imaging Lab include sample analysis and generation of highly detailed images as well as complete sample preparation. NI Lab staff use the focused ion beam (FIB) to produce extremely fine slices of samples – which can be cut in all three dimensions – for later analysis with the STEM. Biological samples must first be embedded in resin. Thanks to their collaboration with the Bio EM Lab, the NI Lab is also equipped to perform this part of the sample preparation process.

The STEM is ready for operation and the first research groups from the University of Basel are currently preparing their initial samples. Companies from across the region have also taken an interest in the microscope and are currently in negotiations with the NI Lab.

Dr. Marcus Wyss, who joined the NI Lab team in summer of 2021 after working as a postdoc in the group under Argovia Professor Martino Poggio, serves as the main point of contact for any issues involving the new microscope. He is currently immersing himself in the subject. Early next year, he will visit the Netherlands to learn additional tips and tricks for using the STEM to work on nanowires from experts at the Eindhoven University of Technology. “I’m excited about all the different research questions we’ll be able to explore using the new STEM, and I’m looking forward to helping our clients from different fields conduct their analyses,” says Marcus Wyss.

New feature at the Technorama

Scanning electron microscope offers a glimpse into the micro and nano world

The Swiss Science Center Technorama in Winterthur has recently acquired a scanning electron microscope (SEM), which can be used to view tiny surface structures in fine detail. With this new device, seemingly smooth surfaces become wild mountain ranges and dust mites and ants are transformed into terrifying monsters. This purchase was made possible by a donation drive initiated by Gloor Instruments. Together with Gloor Instruments itself, the Swiss Nanoscience Institute (SNI) was one of the largest contributors. Additionally, the SNI team from the Nano Imaging Lab is assisting Technorama staff in the operation of the new device. The Technorama crew, in cooperation with the SNI Outreach team, is planning joint workshops in which the new SEM will play a starring role.

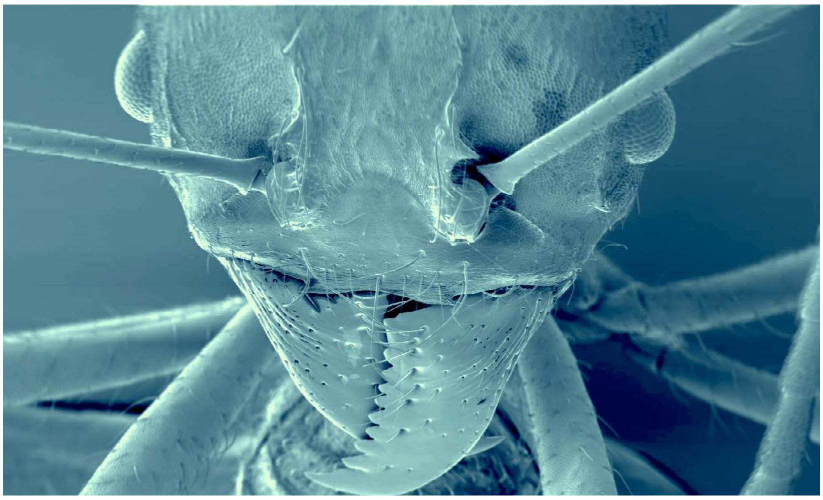
From miniscule critter to towering behemoth

Everyone is familiar with the fascinating images of tiny insects and arachnids whose hypnotizing gaze and enormous claws or feelers lend them the appearance of dangerous monsters. Precise images such as these, which reproduce every infinitesimal hair in crystal clear detail, are made using a scanning electron microscope (SEM).

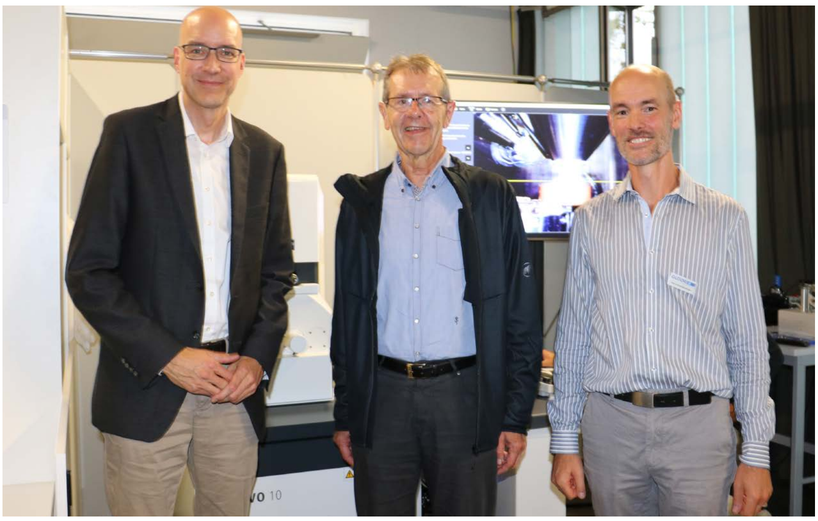
Scanning electron microscopes use a fine, focused beam of electrons to scan the sample one row at a time. Interactions between the electrons and the sample provide information about the properties of the object's surface.

The Technorama in Winterthur, one of Europe's largest science centers with a reputation extending far beyond Swiss borders, now hosts just such a device. The Swiss Nanoscience Institute made a substantial contribution to the purchase of the microscope and continues to provide additional support to the Technorama team.

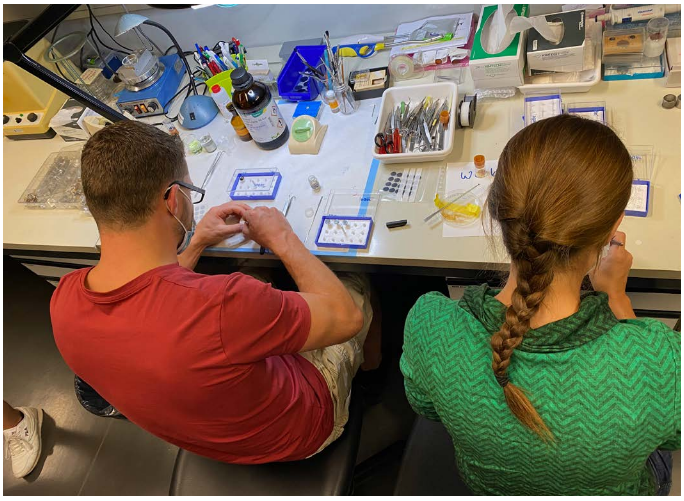
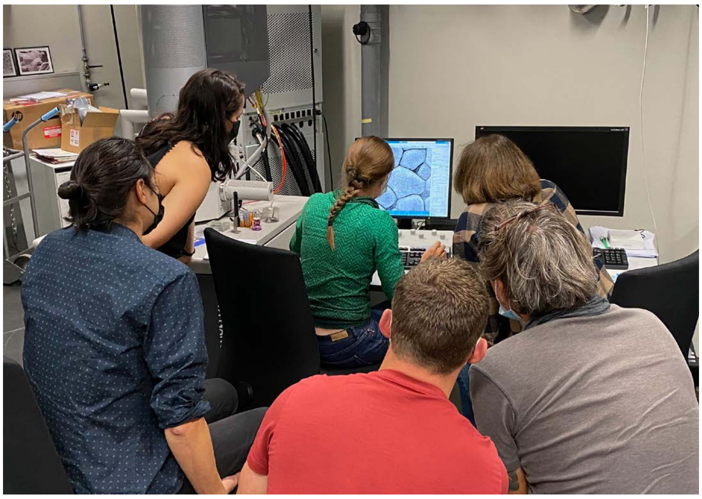
This SEM is also equipped with an energy dispersive X-ray microanalysis (EDX). The EDX is used to analyze the composition of a sample, for instance, to find out what metals are present in a piece of jewelry.



When viewed under the SEM, tiny ants appear far more imposing than they normally do. (Image: Nano Imaging Lab, SNI, University of Basel)



Thorsten-D. Künnemann (Technorama), Christian Schönenberger (SNI) and Harry Brandenberger (Gloor Instruments) present the new SEM at a special ceremony. (Image: K. Beyer-Hans, SNI).

The team from the Technorama attended a workshop in the SNI's Nano Imaging Lab where they received a primer on sample preparation and operation of the SEM.

Gloor Instruments launched donation drive
SNI's new collaboration began with an inquiry from CEO of Gloor Instruments Dr. Harry Brandenberger, who was seeking sponsors to help purchase the scanning electron microscope for the Technorama. It was immediately clear to SNI Director Professor Christian Schönenberger that this investment would be the perfect way to get young people interested in and passionate about the natural sciences. He agreed on the spot. Numerous other companies and private donors contributed to the drive, raising a total of over CHF 150,000 for the investment.

Briefing by the Nano Imaging Lab
Meanwhile, the SEM is installed and six members of the Technorama staff have received thorough training from the experts at the SNI Nano Imaging Lab.

"The team at NI Labs gave us an excellent primer on conducting practical work with the SEM and provided us with an overview of how to prepare different types of samples," says Kim Kaltenbach from the Technorama biology lab, where the SEM is now housed.

The next step is to make these fascinating tiny structures – ranging from millimeters to nanometers in size – available for guests to see with their own eyes. "During our pilot phase, we'll ask individual visitors whether they're interested in working on the SEM themselves," reports Kim Kaltenbach.

Workshops on different topics in the works
How the visitors answer that question will determine what happens next. Either way, the staff from the Technorama plans to work together with the SNI Outreach team to develop workshops in which teachers and students of all ages have the opportunity to do their own work on the SEM and explore different research questions.

The new SEM will offer Technorama visitors a glimpse into the incredible world visible only at the scale of the micrometer and the nanometer.

Further informationen:

Technorama
https://www.technorama.ch/en/home

Nano Imaging Lab SNI
https://nanoscience.ch/en/services-2/nano-imaging-lab/

"We are very pleased that our donation and upcoming collaboration will offer us another means of sharing our fascination for this world of tiny structures with a wider audience."

Christian Schönenberger, SNI Director

Finally face-to-face again
Annual Event and Nano Tech Apéro

Last year, the two most important events in the SNI network – the Annual Event and the Nano Tech Apéro – were cancelled due to the COVID-19 pandemic. As both events hinge not only on the pure exchange of information, but also on personal introductions, discussions and networking, the SNI management decided against holding either of these meetings virtually. This year, however, with the appropriate health and safety measures in place, both conferences could proceed as planned.

Large group meeting at the Schweizerhof
Around 90 SNI members attended this September's Annual Meeting at the Hotel Schweizerhof. Unlike in other years, current restrictions did not allow for all participants to gather in a single room to attend the presentations. This, in turn, presented greater technical challenges than past events. A few technical issues cropped up here and there, but the team under main organizer Dr. Michèle Wegmann was able to dispatch them in no time.

Participants engaged in lively discussions at the presentations and poster session, and during the event, Professor Henning Stahlberg (EPFL) was awarded honorary SNI membership for his dedication to the nanosciences and the nanosciences program in Basel. Among the group of doctoral students, Vanni Doffini received the award for the "best talk" while Thomas Mortelmans won the prize for "best poster." Timon Baltisberger received the Outreach Award.

Participants finally had the chance to interact and exchange ideas in person again.

Further information:

Video Annual Event
https://youtu.be/1gDrcNNy2sM

Henning Stahlberg was named honorary member of the SNI. Vanni Doffini received the award for "best talk" and Timon Baltisberger won the Outreach Award.

The Nano Tech Apéro was held at Omya this year. All participants were treated to a preview of Omya's research activities and learned about new developments in the SNI's applied Nano Argovia projects.

Visiting Omya

This year's SNI Nano Tech Apéro was hosted by the company Omya in Egerkingen at the end of October.

Following a brief introduction to the work of both the SNI and the host company, participants were treated to a fascinating tour of Omya's laboratories. Omya's main product is calcium carbonate, and in its superbly outfitted facilities, the company conducts research on diverse new applications for clients from a wide range of different sectors.

Omya served as an industry partner to the Nano Argovia project KOKORO and participated in the development of an artificial heart, which was built by culturing muscle cells on a paper scaffold, which would subsequently be folded into a flexible tube using a technique derived from the art of origami. This project was one of the applied research projects presented at the Nano Tech Apéro. In addition, participants learned more about the current results of the Nanocompass, UltraNanoGRACO and SiNPFood projects.

Other project leaders held brief presentations on their own Nano Argovia projects. The Apéro offered guests plenty of opportunity to discuss these approaches alongside the poster presentations, share information with one another and perhaps even conceive of new project ideas.

Further information:

Video Nano Tech Apéro
https://youtu.be/o349POaB-dQY

Nano Argovia program
www.nanoargovia.swiss

"It was wonderful and informative to be able to see the doctoral students and colleagues from other institutions in person again and discuss their research."

Christian Schönenberger, SNI Director

Master's graduation ceremony
A well-deserved celebration

Further information:

Description of the award-winning master's theses:

Charlotte Kress:
https://nanoscience.ch/en/2021/05/11/one-eye-on-application-charlotte-kress-thrives-at-the-intersection-between-classical-disciplines/

Anna Leder:
https://nanoscience.ch/en/2021/05/11/folding-proteins-anna-leders-fascination-with-structural-biology/

Video
https://youtu.be/HDd-LpAk2CM

Daniel Stähli:
https://nanoscience.ch/en/2020/08/04/exploring-the-aging-process-daniel-stahli-wins-award-for-the-best-masters-thesis/

Video
Master's program
https://youtu.be/jjbz1DKJ3Qc

This year, we were finally able to hold an apéro to celebrate the graduation of our master's nanosciences students from the past two years. In November, the Study Coordination team led by Dr. Anja Car and Simone Chambers invited over 30 master's graduates to attend a party held at the Wildt'sche Haus.

The trio of musicians from the Patrick Joray Jazz Band set the tone for the event, and Professor Christian Schönenberger presented all 19 graduates in attendance with their degree certificates and a small gift. The winners of the award for best master's thesis in the nanosciences from the past two years, Anna Leder, Charlotte Kress and Daniel Stähli received an additional commendation from their supervising professors.

Aside from the more formal part of the evening, the graduates, along with their friends and relatives, enjoyed ample opportunity to reflect on their last few years at the University of Basel, socialize and simply savor this fun, festive finale to their studies.

"Anyone who wants to achieve great things needs to have a vision, and to develop that vision, we must have both knowledge and courage as well as a positive mindset. I strongly believe that our graduates are possessed of all three; they are fully equipped with the skills they need for a successful career."

Dr. Anja Car, Nanoscience Coordinator, Study Coordination team

Graduates of the nanosciences program enjoyed a celebratory event to celebrate the completion of their master's degrees.(Image: K. Schad)

Hands-on
Public relations returns to public spaces

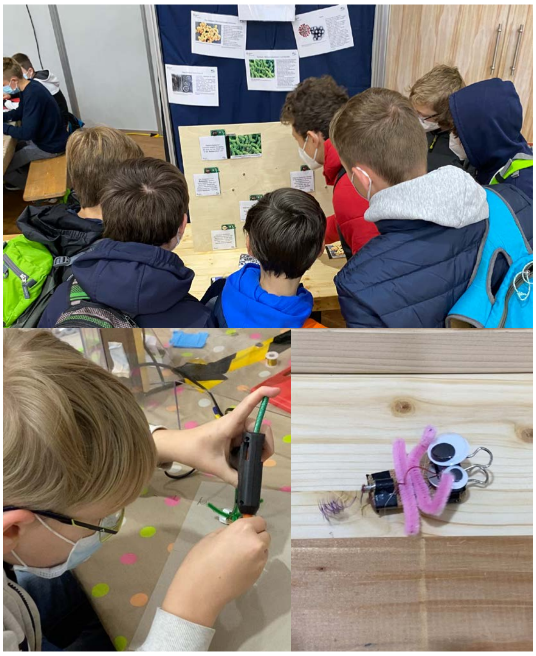
Following an extended break, the SNI's Outreach team is back to meeting with children and students live and in person. Alongside TecDays, the SNI team primarily focused on the events planned in collaboration with Museum Burghalde in Lenzburg, where team members engaged in experiments and activities designed to spark children's interest in the natural sciences.

In August, for example, the team participated in the big soap weekend at Museum Burghalde in Lenzburg. SNI Outreach Managers Dr. Kerstin Beyer-Hans and Dr. Michèle Wegmann offered a lively selection of activities related to soap. Soap experiments were also the focus of a workshop for school classes held in mid-November that was developed by the SNI in partnership with the museum. This event was part of Museum Burghalde's special exhibition on soap, "Saubere Sache," in which the SNI played an active role. The exhibition is open through 31 December 2021.

SNI will continue its collaboration with Museum Burghalde next year. All participants are eager to begin preparations for the new special exhibition "Wasser – Voller Energie" focused on water and energy.

Science Days took place again this year at Germany's Europa Park Rust. At the SNI booth, children had the chance to craft artificial microbes that whizzed around with the help of a vibration motor. The SNI team also created fun presentations on bacteria, fungi and viruses. Many visitors were astounded by the fact that these organisms do more than simply cause trouble for humans – some are even extraordinarily useful.

At the soap weekend in Lenzburg, everything revolved around soap – and activities took on all kinds of forms. (Image: M. Wegmann)



At the Science Days, the SNI provided information about bacteria, viruses and other microorganisms. All the children were able to design a fantasy bacterium that also moves thanks to a vibration motor. (Image: K. Beyer-Hans, SNI)

Further Information:

Museum Burghalde in Lenzburg
https://www.museumburghalde.ch

Exhibition «Saubere Sache»
https://www.museumburghalde.ch/ausstellung/saubere-sache.html

Planned exhibition «Wasser – Voller Energie»
https://www.museumburghalde.ch/ausstellung/wasser-voller-energie-2.html

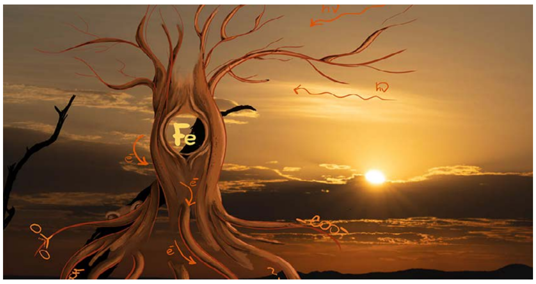
Science Days 2021
https://www.science-und-technologie.de/science-days-vor-ort

News from the network

An ironclad future

Solar energy plays an important role in the fight against climate change as a substitute for fossil fuels. Dye-sensitized solar cells promise to be a low-cost supplement to the photovoltaic systems we know today. Their key feature is the dye sensitizers attached to their surface. Researchers at the University of Basel continue to improve the performance with sensitizers using iron – a commonly available and environmentally friendly metal.

Media release University of Basel:
https://nanoscience.ch/en/2021/11/18/university-of-basel-news-an-ironclad-future/

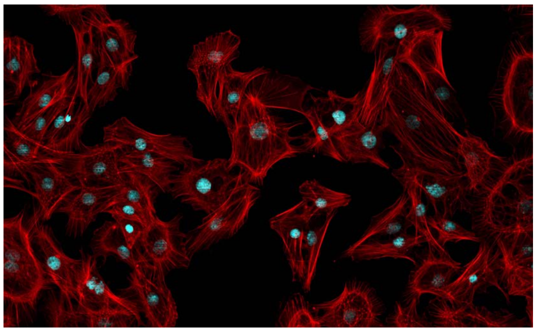


The promising new solar cells rely on iron compounds as sensitizers. They are bound to the semiconductor via carboxylic acid groups. In addition, branched alkyl groups optimize the arrangement of the compounds on the surface. (Image reproduced with the permission of the Royal Society of Chemistry)

Conductive nanocomposites as additives in 3D-biofabricated tissues

Scientists from the SNI network published a review paper on nanocomposites for tissue engineering. They summarize in the science journal *Advanced NanoBioMed Research* how conductive nanocomposites are currently used for the preparation of printable, electrophysiological tissues.

Original article in *Advanced NanoBioMed Research*:
https://onlinelibrary.wiley.com/doi/10.1002/anbr.202100108



In his PhD project, Fabian Züger focuses on mimicking the cellular composition of the heart using 3-dimensional bioprinting. (Image: F. Züger, FHNW and University of Basel)

Advent quiz

This holiday season we will be presenting an Advent quiz on our social media channels. Each Sunday another candle is lit. The motifs on the candles each lead to one of the holiday experiment videos prepared by the SNI team. Participants who submit the correct answers are eligible to win a powerbank and a small surprise.

In addition to experiments with candles, one video includes an instruction for a creative baking activity. Budding bakers can order an SNI craft kit containing all the technical ingredients you need to give your Christmas cookies the gift of mobility. Curious? Try it out for yourself!

Advent quiz
https://nanoscience.ch/de/ueber-uns/raetsel/

Experiment videos:
https://nanoscience.ch/de/ueber-uns/experimente-und-bastelei-en-zu-hause/

Order form craft kit
https://nanoscience.ch/de/bestellung-bakeneering-weihnachts-maeuse/

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