2025 Annual Report

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adolphe merkle institute
excellence in pure and applied nanoscience

About the Adolphe Merkle Institute

The Adolphe Merkle Institute (AMI) is an independent competence center at the University of Fribourg that focuses on research and education in soft nanomaterials.

We owe our existence to Dr. Adolphe Merkle, a successful local entrepreneur who established the Adolphe Merkle Foundation to strengthen research and teaching at the University of Fribourg. His CHF 100 million endowment is among Switzerland's most important private donations in support of academic research.

Founded in 2008, AMI is, in many respects, unique in Switzerland's research landscape. Our focus on soft nanomaterials is unmatched in Switzerland and beyond. Our research combines fundamental and application-oriented aspects in a multidisciplinary setting. Through collaborations with industrial partners, AMI aims to stimulate innovation, foster industrial competitiveness, and improve the quality of life.

Our researchers are currently organized into five primary and two junior research groups, which offer complementary expertise and interests in strategically important areas: BioNanomaterials, Polymer Chemistry and Materials, Soft Matter Physics, Biophysics, Food Science and Technology, Mechanoresponsive Materials, and Quantum Sensing & Spin Chemistry. Interdisciplinary collaborations between our researchers are the basis for the successful and efficient execution of complex research projects that transcend the boundaries of traditional scientific disciplines. This environment and world-class research facilities make AMI a desirable destination for master's and PhD students, postdocs, and senior researchers.

Table of contents

Building networks
_ A message from the Director

Prof. Ullrich Steiner

Dear reader,

It is with pleasure that I present the latest annual report from the Adolphe Merkle Institute. In it, we reflect on the most significant activities, achievements, and developments of the previous year.

As always, our research remains central to the report. The Polymer Chemistry and Materials group successfully completed a four-year project with colleagues in Thailand, developing intelligent membranes that control moisture flow. Our Mechanoresponsive Materials group has established long-term research collaborations. The Soft Matter Physics group has been investigating polymers that can change colour in response to magnetic fields. The BioNanomaterials group has developed an innovative method to increase the likelihood of nanoprobes used for diagnostics surviving their journey through the human body. The BioPhysics team has continued its work on nanopores to unlock the secrets of folded proteins and facilitate pharmaceutical development.

You will also be able to read about AMI's contributions to global nanosafety and how our outreach activities foster a better understanding of STEM research and encourage young people to pursue careers in science. Finally, you will have the opportunity to meet our new AMI Chair of Food Science and Technology, Professor Hans Jörg Limbach, who will discuss his plans to strengthen Fribourg's presence in the food sector.

Further coverage of some of our achievements can be found in the "In Brief" section, which highlights events from the past year, including networking opportunities abroad, promotions for researchers and alumni, and appointments to consultative and deliberative bodies.

I hope you enjoy reading this report, the last one that I sign off as AMI Director. It has been an honour to lead the Institute with the support of my colleagues over the last four years. I wish my successor, Professor Limbach, all the best in his new role. Thank you again for your interest in our institute, our team, and our activities.

Prof. Ullrich Steiner
AMI Director and Chair of Soft Matter Physics


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Pursuing excellence

New Chair

_ Developing a sustainable food system


Prof. Limbach is seeking to work with local partners in the food sector

Prof. Hans Jörg 'Hanjo' Limbach joined the Adolphe Merkle Institute in 2025 as the new Chair of Food Science and Technology. Limbach brought extensive industry experience, having worked in food research at the Swiss multinational Nestlé for 20 years. His appointment signaled AMI's strategic expansion into food innovation, leveraging its expertise in soft nanomaterials to address global food challenges. Among his goals are contributing to a more sustainable food system with less waste and developing collaborations with local industry partners.

What attracted you to the Adolphe Merkle Institute?
Hanjo Limbach: There were three main aspects that excited me about the Adolphe Merkle Institute. First, there is the vision of Adolphe Merkle, who intended to foster fundamental science, paired with a strong drive to translate it into applications that would benefit the canton's local economy. Second, it was amazing to see the strong international scientific reputation in materials science that my current colleagues have built over the past few years. And third, I believe in collaboration and synergies between different points of view. The interdisciplinary setup at AMI, with chairs having widely different backgrounds in one building, is unique in the field and a key aspect that I already enjoyed during my time in industry.

Why move from industry back into academia?
I very much enjoyed my work in industry. One aspect is that I am a very curious person, and I always need new challenges. The great thing about academia is the freedom to dig much deeper into the scientific understanding of problems than in an industry research setting, even when it is not possible to know which applications these new insights could be used for. And then there was also the possibility to make a contribution by training great young talents and sharing my practical experience from my time in industry.

How did your past experience prepare you for this new role?
One of the great aspects of working for a large multinational company is the opportunity to gain experience across a wide range of areas. In my case, I was fortunate to work on almost all aspects of the innovation value chain: from basic research and product devel-

opment to consumer insights, research strategy, and business model development, all the way to designing a large-scale industrial manufacturing line. I also learned a lot about leadership, project management, and working with people and teams. And in a large, complex organization, soft skills and what we call 'transversal leadership' are, in the end, more important for success than your hierarchical position. I strongly believe that a holistic approach to problem-solving and a leadership style that builds on individual respect are good starting points for a strong research team.

What is the main goal of your chair?
We want to contribute to the development of a sustainable food system that benefits both people and the planet. Today our typical Western diet is too strongly based on animal-based food, which renders it not sustainable from an environmental point of few. To illustrate this – around 60% of our protein intake arises from animal based food. We want to create new, exciting food products using plant-based ingredients to give people more options to move towards a more sustainable and healthier diet. Many food products are currently based on highly purified ingredients that use only a limited fraction of the biomass originally produced. An example is soja-lecithin, a component of the soybean. Why can we not use the entire soybean and functionalize its inherent lecithin via smart food processing? A key aspect is that we still produce too much food waste at every step of the food value chain. And this is not just at the consumer level. How can we avoid this food waste in the first place, and how can we valorize unavoidable side streams? And these are just some of the key questions that will drive our research efforts in the new Food Science & Technology team.

What are some of the research topics your group is tackling?
We are still a small team, but we have already started a few projects. Proteins are one of the most amazing and versatile food ingredients – and on top they help to make food more nutritious. In one of our projects, we want to find out why specific plant proteins work better in certain food products – for example, in helping to stabilize an emulsion. Plants, and in particular legumes such as beans and lentils, provide a large variety of proteins, and we still know too little about their functionalities.

Freezing is one of the best ways to preserve foods without using large amounts of sugar, salt, or fat. But freezing often destroys the structure of food, for example, in fruit. For this project, we want to flip the script and investigate how we could use freezing to create new food structures with interesting and exciting textures. One example would be reducing extraction and extrusion processes during the creation of plant-based meat-like textures.

How will your group work with local companies and the regional food ecosystem?
The canton of Fribourg has a vibrant food ecosystem where a group with a focus on fundamental science can both participate proactively and draw some benefits. This starts with other players in the education and research sector, such as the cantonal agricultural school, the Federal Agricultural Research Center Agroscope, and the Fribourg Engineering and Architecture School, which we need as partners with strong experience in translating research into applications. Then there are several key players in the public sector who help build networks and provide significant support for knowledge transfer. The Food and Nutrition Cluster, Fri Up, which supports local start-ups, and the Fribourg Development Agency (FDA), to name just a few. And with the inter-faculty Food Research and Innovation Center (FRIC), we also have a truly interdisciplinary setup within the University, covering aspects of food innovation beyond materials science, such as health, psychology, and marketing.

Overall, I am looking very much forward to working with these partners, and we are open to collaborations. This can be in the context of an InnoSuisse or Bridge project or in the frame of a direct project for a Master- or PhD-thesis. But we are also interested in small projects for proof-of-concept studies and specific consultancies regarding food processing and product development. We have already reached out to several local companies and start-ups to better understand their needs and to discuss first ideas for common projects. Ultimately, we want our work to benefit both local communities and consumers everywhere.

Prof. Hans Jörg Limbach is the Director of the Adolphe Merkle Institute since June 1, 2026, taking over from Prof. Ullrich Steiner.

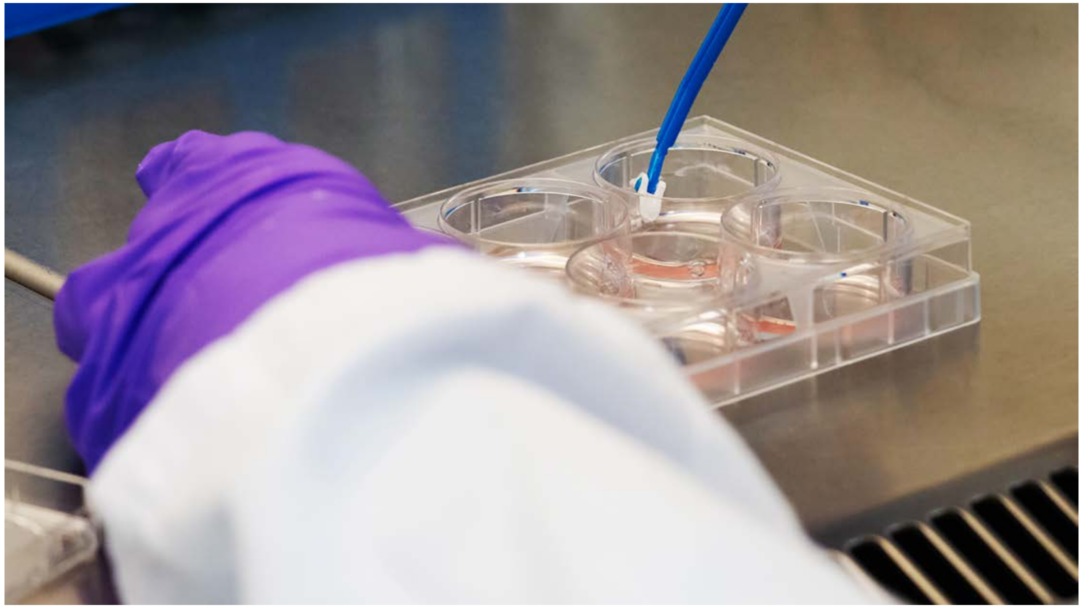
Suggested reading

Leroy, F. *Animal foods in contemporary diets: how much?* Aleph **2020**

te Wierik, S.; DeClerck, F.; Beusen, A.; Gerten, D.; Maggi, F.; Norberg, A.; Noone, K.; Schulte-Uebbing, L.; Springmann, M.; Tang, F. H. M.; de Vries, W.; van Vuuren, D.; Vermeulen, S.; Rockström, J. Identifying the Safe Operating Space for Food Systems. *Nat Food* **2025**, 6 (12), 1153–1163.

Improved safety

_ Contributing to global standards



Understanding how nanoparticles behave in biological environments is critical for nanosafety testing

The Organization for Economic Cooperation and Development (OECD) recently released a crucial update of its safety testing framework for nanotechnology. The Adolphe Merkle Institute's Co-Chair of BioNanomaterials, Prof. Alke Fink, contributed to the OECD expert group developing these revised standards, ensuring they reflect how nanoparticles actually behave under realistic experimental conditions.

The OECD's newly released guidance establishes how nanoparticles should be prepared, characterized, and dosed to ensure they're safe as the technology expands into medicine, imaging, catalysis, advanced polymers, sensing, and other fields of use. For the framework's authors, nanoparticle safety testing only works when sample preparation, physicochemical characterization, and dosimetry are treated as one integrated process. This is particularly important since nanoparticles can undergo changes at their surface, as well as in their dispersion state and stability, once they enter biological or physiological media containing proteins, salts, and other components.

"Reliable characterization in relevant media is central to nanosafety testing, especially in biological systems," explains Fink, who was a member of the organization's expert group. "Many commonly used biological assays were not originally developed for testing nanoparticles, particularly under realistic biological conditions."

The OECD updated its guidance, as research over the past decade has shown that nanoparticles behave very differently from classical chemicals. And without harmonized protocols for preparation, characterization, and dosimetry, results for safety evaluation are often not comparable across laboratories, and biological effects cannot be reliably interpreted. For example, nanoparticles' properties can change during an experiment, making their continuous characterization in the relevant media crucial.

"Preparation and dosimetry are essential, but without proper characterization, you cannot know what actually reaches the cells or in what amount," adds Fink.

Fink specifically contributed her specialized expertise in nanoparticle characterization under realistic biological conditions. This includes colloidal stability, nanoparticle–protein interactions, and practical dispersion and dosimetry strategies. Her contribution supported the expert group's efforts to ensure that the recommendations reflect both current scientific understanding and workable laboratory practice.

Looking ahead, implementing the updated guidance will require continued attention to nanoparticle characterization under realistic exposure conditions. Because particle surface properties and dispersion state depend strongly on the surrounding medium, no single universal protocol can cover all materials and applications. Researchers will need interdisciplinary expertise and careful experimental design to ensure that preparation, characterization, and dosimetry remain aligned throughout a study. While this adds scientific complexity, the framework provides a common reference point that strengthens the transparency, reproducibility, and global comparability of nanosafety data.

Reference:

Guidance on Sample Preparation and Dosimetry for Manufactured Nanomaterials, 2025 Edition, OECD Series on the Safety of Manufactured Nanomaterials and other Advanced Materials, OECD Publishing, Paris

26

NATIONALITIES

PRESENT AT AMI WITH REPRESENTATIVES FROM EVERY INHABITED CONTINENT.

7

PROFESSORS

WORKING ACROSS THE FIELDS OF POLYMER SCIENCE, MATERIALS, PHYSICS, CHEMISTRY, BIOLOGY, AND FOOD SCIENCE.

59%

OF ALL RESEARCH EXPENDITURES

WERE COVERED BY THIRD-PARTY FUNDING. SOURCES INCLUDED THE SWISS NATIONAL SCIENCE FOUNDATION, THE EUROPEAN UNION, INNOSUISSE, AND INDUSTRIAL PARTNERS.

6,785

CITATIONS

OF AMI PUBLICATIONS IN THE SCIENTIFIC LITERATURE IN 2025.

4

APPLICATION-ORIENTED

PROJECTS

FINANCED BY INNOSUISSE, THE SWISS INNOVATION AGENCY, AND OTHER PARTNERS.

67

SCIENTIFIC PUBLICATIONS

IN TOP-RANKED JOURNALS SUCH AS ANGEWANDTE CHEMIE, ACS NANO, CHEMICAL SOCIETY REVIEWS, ADVANCED FUNCTIONAL MATERIALS, CHEMISTRY OF MATERIALS, ENVIRONMENTAL SCIENCE AND TECHNOLOGY, ADVANCED MATERIALS, AND NATURE CHEMISTRY.

530+

ALUMNI

INCLUDING POSTDOCTORAL RESEARCHERS, PHD STUDENTS AND INTERNS.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Outreach
_ Bringing science to a wider public

Doing the particle dance: AMI researchers joined the biggest outreach event of the university year in Fribourg, Explora

From KidsUni lectures for primary school children to three-minute thesis pitches and art-science exhibitions, the Adolphe Merkle Institute has turned STEM outreach into a year-round experiment in bringing science to the wider public.

AMI actively participates in initiatives to spark young children's and teenagers' interest in science and to promote STEM (Sciences, Technology, Engineering, and Mathematics) careers. The programs not only include teaching children and students but also the training of elementary school teachers. And since Fribourg is a bilingual city, AMI's outreach and educational activities to elementary and high school students are offered in German and French.

The most notable example of this is KidsUni at the University of Fribourg. It was co-founded by our Bio-Nanomaterials Co-Chair, Prof. Alke Fink, with Prof. Andreas Kilbinger of the University's Department of Chemistry. With the financial support of the National Center of Competence in Research (NCCR) Bio-Inspired Materials, based at the Institute, for the past 12 years, this initiative has grown to embrace physics, chemistry, biology, materials science, geosciences, math, computer science, neuroscience, and architecture. Workshops with simple experiments or concepts for children aged 9–11 are regularly organized throughout the year. For the 2025–2026 academic year, there were, for example, 12 different workshops to choose from. AMI staff took part in those related to materials science and microscopy.

Reaching all age groups

Teenagers are also included in AMI's outreach efforts. The institute regularly hosts students in their fifth year of high school studies as part of the University's Science for Youth program. At AMI, the students are given experiments to perform under the guidance of our technicians, PhD students, and postdocs.

Schweizer Jugend Forscht, a national competition for college students, also passes through AMI. For some of the students working on materials science projects, the institute opens its doors for a study week and welcomes them into our laboratories. AMI also traditionally hosts the week's final event, where the students present their projects. Young adults can also work on their college end-of-studies projects at AMI under the guidance of our PhD students and postdocs.

Younger children will soon also be able to take part in the new FriMINT program, helmed by AMI group leader Dr. Viola Vogler-Neuling and Prof. Pitt Hild of the University's Faculty of Education. The goal is to set up a science laboratory for primary school children between the ages of four and eight over the next two-and-a-half years.

Upon request, AMI also helps with teacher training. For example, the institute welcomed in 2025 chemistry teachers from Etoy College in canton Vaud for an afternoon of hands-on experiments that could be conducted outside the laboratory.

The institute also regularly participates in the University's culture, science, and society festival Explora, an open day held every other year on campus. In 2025, it took place at the University's Miséricorde site, where AMI had a stand featuring hands-on activities in physics, food science, biology, and materials science.

Taking science to the people

AMI researchers are also involved in promoting STEM outside the institute. The Swiss Academy of Engineering Sciences organizes its TecDays at colleges across the country, offering a wide variety of workshops in science and engineering. AMI professors are regular participants, speaking to students about nanoscience and material science.

AMI staff have participated in the Pint of Science festival in Fribourg as speakers or members of the organizing team. This is an annual international science festival that brings researchers to local bars or cafes to share some of the latest scientific discoveries in science.

PhD students and postdocs have also been able to hone their pitching skills at events such as "Ma thèse en 3 minutes" (three-minute thesis in French) and the Science Slam at the University of Fribourg, or the Falling Walls Western Switzerland competition, organized by the NCCR and hosted at AMI for the past three years. For this last competition, the winners travelled to Berlin to face off against researchers from around the world in the annual global final.

Art and science

Science and culture have also been a theme, in 2024 with the NanoARTS project in partnership with Pro Helvetia, the Swiss Arts Council, and, more recently, an art and science collaboration organized by the NCCR, which included AMI researchers, with visual arts students from Fribourg's St Michel and Gambach colleges creating artworks with input from scientists. The results were shown in two exhibitions held in Fribourg.

AMI researchers also speak at conferences and events for non-specialists. This can range from Fribourg's Belluard-Bollwerk arts festival in the past to presenting research inspired by electric fish at an event organized by the canton's Chamber of Commerce and Industry during the 2026 World Ice Hockey Championships in Switzerland.

Finally, AMI also regularly welcomes groups of visitors wishing to tour our site and learn more about our research. This can range from VIPs, such as ambassadors visiting the canton and parliamentary committees, to small associations. The institute was visited in 2025, for example, by the United Kingdom's ambassador to Switzerland, James Squire, the Swiss Association of Physics Technicians, and representatives from biopharmaceutical multinational UCB's local quality assurance team.


FRIBOURG
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49

ACTIVE RESEARCH PROJECTS

SUCH AS BIO-INSPIRED MATERIALS, PHOTONIC STRUCTURAL MATERIALS, MECHANOCHEMISTRY, SUPRAMOLECULAR POLYMERS, DETECTION AND CHARACTERIZATION OF NANOPARTICLES, NANOPORE FABRICATION, SINGLE-MOLECULE DETECTION, IN VITRO TESTING, TISSUE ENGINEERING.

CHF 9.74 M

SPENT OVERALL IN 2025

RESEARCH EXPENDITURES REACHED CHF 8.24 MILLION, A SLIGHT INCREASE OVER 2024.

48%

OF STAFF AT AMI ARE WOMEN

30

SEMINARS

INCLUDING 10 GIVEN BY AMI PhD STUDENTS.

99

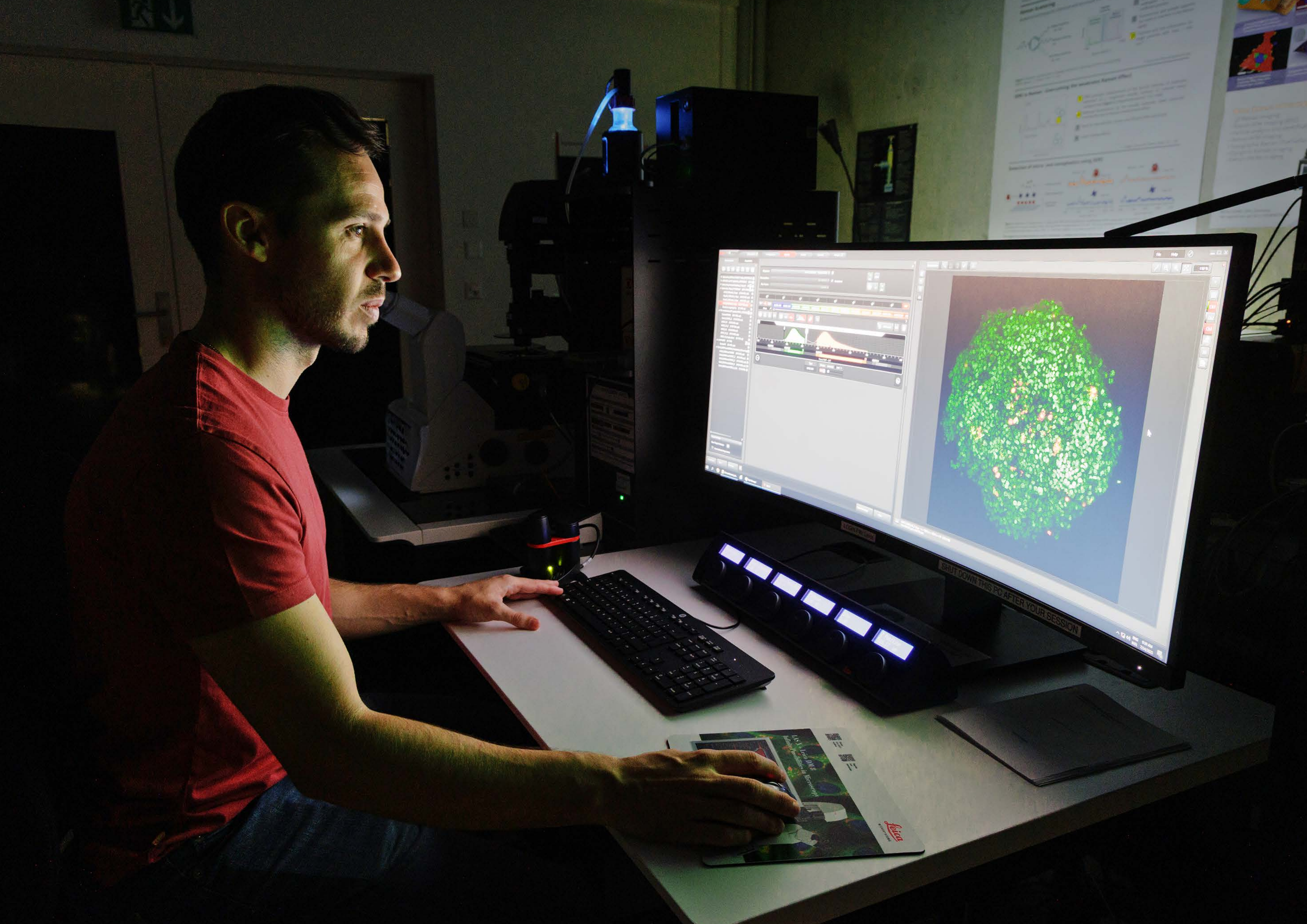
PEOPLE

WORKED AT AMI AT THE END OF 2025 INCLUDING PHD STUDENTS, POSTDOCTORAL RESEARCHERS, PROFESSORS, SUPPORT STAFF, AND INTERNS.

56%

OF OUR RESEARCHERS

ARE DOCTORAL STUDENTS.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19

_Research at AMI

Bio-inspired
_ Intelligent membranes to control moisture flow

Researchers at the Adolphe Merkle Institute and Chulalongkorn University in Thailand have developed a new class of nature-inspired membranes that autonomously control the extent of water transport in response to environmental conditions, with potential applications ranging from healthcare to packaging.

Nature has developed countless strategies for collecting and retaining water, including mechanisms to prevent water loss through transpiration. For example, most land plants are covered by thin protective layers, known as cuticles, that prevent desiccation. Olive trees and ivy leaves possess cuticles that act as intelligent barriers, regulating moisture transport in response to changing environmental conditions. Supported by a Swiss National Science Foundation SPIRIT grant, aimed at fostering international research partnerships, the Swiss-Thai team sought to understand the design principles underlying this remarkable behavior and translate them into synthetic materials. “Our goal was to exploit the principles at play in the olive cuticle as blueprints for the bio-inspired design of artificial membranes, and if possible, improve on nature,” explains Prof. Christoph Weder, AMI’s Chair of Polymer Chemistry and Materials.

Like their biological counterparts, the synthetic membranes developed by the team adapt dynamically to humidity and, owing to their asymmetric structure, preferentially transport water in one direction. Earlier studies by AMI’s polymer researchers had revealed that this directional transport in plant cuticles arises from a subtle interplay between the compositionally graded architecture of the cuticle and humidity-induced softening of its central layer. By recreating these features in artificial membranes, the scientists established a versatile platform for investigating the underlying transport mechanisms and tailoring them through material design.

Working closely across disciplines and continents, the researchers subsequently developed membranes whose directional water transport can be switched on or off simply by changing the surrounding humidity. Rather than relying on pumps, valves, or external power sources, the membranes autonomously regulate water permeation as environmental moisture changes the mobility of selected polymers within them. By carefully controlling the membrane composition and architecture, the team demonstrated that both the magnitude and the directionality of water transport can be tuned over a wide range. These findings not only provide new insights into how plants regulate water loss but also demonstrate adaptive membranes with programmable transport properties and world-record asymmetries.

However, despite the promising results, the researchers acknowledge that hurdles remain. Predicting exactly how these membranes will behave under different conditions is difficult, and the humidity range in which they currently switch is limited.

The responsive membranes could be used wherever passive moisture control is desirable. Potential applications for this new class of membranes are wide-ranging, including packaging that could regulate moisture to extend the shelf life of food or protect electronics, wound dressings that maintain optimal moisture for healing, and systems for oil–water separation and water harvesting in dry regions. Because the membranes operate autonomously and require no electronic control or external energy input, they represent an attractive strategy for developing sustainable materials inspired by the elegant solutions evolved by nature over millions of years. The project also illustrates how international collaboration, bringing together complementary expertise in plant biology, polymer science, and materials engineering, can transform fundamental biological discoveries into innovative technologies with real societal impact.

References:

Grillo, L.; Weder, C. Directional Water Transport in Laminated Polymer. *Journal of Membrane Science* **2025**, 733, 124379.

Rattanaphong, N.; Grillo, L.; Weder, C.; Dubas, S. T. Directional Moisture Transport in Compositionally Graded Multilayer Membranes. *ACS Appl. Polym. Mater.* **2025**, 7 (24), 16628–16636.

Luca Grillo joined the Polymer Chemistry and Materials group as a PhD student in 2021 as part of the SPIRIT project. He successfully defended his thesis his PhD thesis “Bio-inspired compositionally graded membranes with directional water transport characteristics” in March 2026.

Polymers

Team

Prof. Christoph Weder, Prof. Jose Berrocal, Dr. Tansu Abbasoglu, Luca Bertossi, Veronique Buclin, Dr. Linlin Deng, Jonas Eschmann, Matilde Folkesson, Dr. Georges Formon, Luca Grillo, Dr. Manon Guivier, Xueqian Hu, Thijs Jonker, Benjamin Ladet, Davide Lardani, Dr. Davide de Luca, Dr. Indradip Mandal, Oindrila Mondal, Chaninya Mak-Iad, Marta Oggioni, Dr. Luis Perez, Dr. Vaishali Pruthi, Anita Roulin, Shohei Shimizu, Nick Zahnd

Key Publications

1. Shimizu, S.; Clough, J. M.; Weder, C.; Sagara, Y. Hinge-Like Mechanochromic Mechanophores Based on [2.2]Paracyclophane. *Angew. Chem. Int. Ed.* **2025**, 64 (37), e202510114.

2. Mak-iad, C.; Bertossi, L.; Formon, G. J. M.; Weder, C. Healable Glassy Metallosupramolecular Polymers. *ACS Macro Lett.* **2025**, 14 (7), 996–1003.

3. Oggioni, M.; Bertossi, L.; Kiebala, D. J.; Kirshner, A.; Dodero, A.; Formon, G. J. M.; Weder, C. Photoacid-Induced Supramolecular Network Disassembly: A Systems Approach to Stimuli-Responsive Polymers. *Angew. Chem. Int. Ed.* **2025**, 64 (30), e202506981.

4. Skandalis, A.; Ayer, M. A.; Weder, C. Bioinspired Adhesives with Debonding-on-Demand Capability. *ACS Macro Lett.* **2025**, 14 (4), 420–427.

5. Hu, X.; Pollice, L.; Ronchi, A.; Roccanova, M.; Mauri, M.; Lardani, D.; Vanhecke, D.; Monguzzi, A.; Weder, C. Confinement-Enhanced Multi-Wavelength Photon Upconversion Based on Triplet–Triplet Annihilation in Nanostructured Glassy Polymers. *Advanced Science* **2025**, 12 (14), 2415160.

Molecular sensing

_ Unlocking the secrets of folded proteins

The Adolphe Merkle Institute's BioPhysics group has developed a new, larger nanopore that could facilitate pharmaceutical development by determining if a drug candidate can inhibit disease-causing functions in proteins.

Proteins are responsible for nearly every function in the human body, from metabolic catalysis to structural integrity and immune defense. Their three-dimensional shapes and volumes largely determine their function, so understanding these structures could unlock treatments for complex diseases. But traditional microscopy methods cannot visualize them.

Other analytical methods, such as dynamic light scattering or mass spectrometry, determine the average characteristics of millions of molecules. They do not, however, provide a precise snapshot of variations or transient states that are signposts of disease progression or drug resistance. Single-molecule analysis overcomes this hurdle, with biological nanopores emerging as the tool of choice. They have the advantage of allowing the observation of proteins in their native state, without resorting to behavior-altering chemical modifications or fluorescent tags.

The sensing mechanism uses two electrolyte-filled compartments, separated by a thin membrane with a single pore. When an electrical potential is applied, ions pass through the pore, generating a current. Proteins passing through the pore cause variations in the current and reduce it. Measuring these changes provides information on the protein's size and shape, but the nanopore's size is a limiting factor.

The AMI researchers investigated a larger nanopore that repurposes a key element of a protein complex – a functional, and often modular molecular syringe needle – that destroys pathogens by puncturing their membranes. The scientists were particularly interested in Poly(C9)'s ability to self-assemble into large tubular structures, which is critical for its function to kill pathogens.

Because the nanopore structure is cylindrical, the system allows measurements of a protein's volume and shape, with its accuracy validated against six well-known proteins. A critical factor in these measurements is the longer time the proteins spend inside the nanopore. The distribution of negative and positive surface charges might create vortices that slow down a protein as it passes through, providing more time to determine its shape and volume.

To demonstrate the nanopore's clinical potential, the researchers chose to study adenylate kinase, an enzyme essential to energy metabolism that exists in two states, open and closed. They blocked the protein in its closed state and compared it to the other state. They found that the Poly(C9) pore, using current modulation analysis, could distinguish between the two.

This could be a significant advantage for drug discovery. "By tracking how a protein's shape changes, we could tell whether a drug candidate locks the target into an inactive form, blocking the biological signals and reactions that contribute to disease," explains AMI's Chair of BioPhysics, Prof. Michael Mayer.

The group now plans to apply this approach to other therapeutically relevant protein targets and assess the ultimate limit of sensitivity of this novel approach.

Reference

Chanakul, W.; Mukhopadhyay, A.; Awasthi, S.; Protopopova, A. D.; Ianiro, A.; Mayer, M. Large and Stable Nanopores Formed by Complement Component 9 for Characterizing Single Folded Proteins. *ACS Nano* **2025**, 19 (5), 5240–5252.

Dr. Anasua Mukhopadhyay joined the AMI BioPhysics group in 2022 as a postdoctoral researcher after completing her PhD at the Indian Institute of Technology in Mumbai. The recipient of an SNSF Spark grant and a Young Investigator Grant from the Novartis Foundation for Medical-Biological Research, she was appointed group leader in 2026.

BioPhysics

Team

Prof. Michael Mayer, Dr. Mariano Barella, Dr. Wachara Chanakul, Olle Dyberg, Prof. Alessandro Ianiro, Dr. Edona Karakaci, Dr.Yuanjie Li, Dr. Pau Molet Bachs, Dr. Anasua Mukhopadhyay, Dr. Liviana Mummolo, Carolina Pierucci, Dr. Anna Protopopova, Dr. John Puguan, Matthieu Sandell, Andela Vracar, Dr. Justus Wesseler, Dr. Lijian Zhan

Key Publications

1. Pierucci, C.; Paleari, L.; Baker, J.; Sproncken, C. C. M.; Folkesson, M.; Wesseler, J. P.; Vracar, A.; Dodero, A.; Nanni, F.; Berrocal, J. A.; Mayer, M.; Ianiro, A. Nafion Membranes for Power Generation from Physiologic Ion Gradients. *RSC Appl. Polym.* **2025**, 3 (1), 209–221.

2. Li, Y.; Ying, C.; Mayer, M. Continuous, Low Latency Estimation of the Size and Shape of Single Proteins from Real-Time Nanopore Data. *Anal. Chem.* **2025**, 98 (1), 224–234.

3. Li, Y.; Awasthi, S.; Liu, P.; Protopopova, A. D.; Mayer, M. Selective and Controllable Trapping of Single Proteins in Nanopores Using Reversible Covalent Bonds. *ACS Nano* **2025**, 20 (1), 879–891.

4. Chanakul, W.; Chantipmanee, N.; Sandell, M.; An, R.; Mayer, M.; Xu, Y. Nanopore Sensing: Current Progress and Future Challenges Tackled by Nanofluidic Devices. *TrAC Trends in Analytical Chemistry* **2025**, 194, 118541.

5. Ngamplang, P.; Basharat, G.; Rungrotmongkol, T.; Mayer, M.; Kornsuthisopon, C.; Chuysinuan, P.; Choipang, C.; Supaphol, P. Controlled Release and Antibacterial Performance of Terpinen-4-Ol/β-CD Liquid Bandages. *ACS Omega* **2025**, 10 (43), 51368–51382.

Special blend

_ Magnetic tunable colors inspired by nature

Adolphe Merkle Institute researchers have developed a simple method to create dazzling hues using polymers, mimicking the behaviour of cuttlefish and octopuses. Possible applications include adaptive camouflage, smart displays, and switchable coatings.

Cuttlefish and octopuses can flash vivid colors and almost instantly disappear into their surroundings thanks to special skin cells called iridophores. These structures contain stacks of nanoscale, transparent layers with alternating refractive indices. When light bounces off these layers, they reflect only specific wavelengths, creating vivid hues without the use of dyes or pigments. Cephalopods can tune their appearance by changing the orientation of these stacks, allowing rapid, reversible shifts in reflected color and directionality, which is central to their adaptive camouflage.

The AMI researchers and colleagues at the University of Fribourg, in Spain, and Italy have created ellipsoidal microparticles that work on the same principle as iridophores. These particles are composed of block copolymers, macromolecules formed from two or more distinct polymer chains (blocks) linked together in a linear sequence. They arrange themselves into axially stacked nanolayers during a simple "one-pot" emulsion process. The key innovation involves adding superparamagnetic nanoparticles to the polymeric matrix, which provides each particle with a built-in magnetic handle.

When a magnetic field is absent, these microparticles float in a liquid with no specific orientation. Their internal stacks still reflect light, but because every particle points in a random direction, the suspension appears whitish due to diffuse scattering. However, when a magnetic field is applied, the particles rotate and align with it. This results in the stacked layers inside each particle sharing a common orientation relative to the incoming light, and the suspension suddenly displays vivid structural colors depending on the spacing of the internal layers.

The researchers' findings show that more widely spaced higher-molecular-weight polymers reflect longer wavelengths towards the red end of the visible light spectrum. Lower molecular-weight polymers with tighter spacing reflect shorter wavelengths on the blue side of the spectrum. By simply blending polymers of different molecular weights at specific ratios, it is possible to smoothly transition across a wide range of hues, from deep blues to vibrant reds, without the need for chemical modifications or dyes.

What makes this technology especially striking is its angle-dependent color, with the reflected wavelength shifting predictably with the orientation angle, like the iridescence seen in the wings of butterflies or hummingbirds. "Because the particles respond to the direction of the magnetic field, tilting the field provides a simple way to dynamically control the color shift," explains Dr. Andrea Dodero, a group leader in AMI's Soft Matter Physics group.

Most previous approaches to color-changing materials have been complicated to fabricate, slow to respond, or dependent on constant power. This new strategy uses commercially available polymers, a straightforward manufacturing route, all the while pointing towards realistic scalability for future potential applications.

These include smart coatings, adaptive camouflage surfaces, anti-counterfeiting features, and display-like optical elements, in which tunable appearance is a key function, according to Dodero. "These are areas where a magnetically switchable color platform may offer something conventional static pigments cannot," he adds.

Dodero points out, though, that the work is not simply about producing colored particles, but about integrating materials design, optical behavior, and magnetic actuation into one coherent concept inspired by biology. "The final result reflects not just multiple disciplines working side by side, but a true convergence of chemistry, physics, and bio-inspired materials design, leading to a system that is both scientifically elegant and application-oriented," he says.

Reference

Mazzotta, G.; Bertucci, S.; Mendoza-Carreño, J.; Mihi, A.; Lova, P.; Comoretto, D.; Steiner, U.; Lattuada, M.; Dodero, A. Bio-Inspired Magnetically Tunable Structural Colors from Elliptical Self-Assembled Block Copolymer Microparticles. *Adv. Funct. Mater.* **2025**, e28686.

Dr. Andrea Dodero joined the AMI Soft Matter Physics group in 2021, before becoming a group leader in 2022, the same year he was awarded a prestigious Marie Sklodowska-Curie Individual Fellowship. Dodero earned his PhD at the University of Genoa in Italy, where he investigated biomedical, pharmaceutical, and food-related applications of polysaccharide-based materials.

Soft Matter Physics

Team

Prof. Ullrich Steiner, Bilel Abdennadher, Viola Bauernfeind, Federica Bortoletto, Nicolas Bruder, Victoire de Cabannes de Cauna, Emma Contini, Dr. Andrea Dodero, Vincent Glauser, Florin Hemmann, René Iseli, Thomas Kainz, Cristina Prado, Kumar Praveen, Dr. Rushna Quddus, Dr. Nadine Rassmann, Dr. Matthias Saba, Ahmed Salem, Cedric Schumacher, Niklas Schwarz, Dr. Viola Vogler-Neuling

Key Publications

1. Airoldi, M.; Berrocal, J. A.; Gunkel, I.; Steiner, U. Polymer-Based Solid Electrolyte Interphase for Stable Lithium Metal Anodes. *RSC Appl. Polym.* **2025**, 3 (1), 278–288.

2. Bertucci, S.; Escher, A.; Bravetti, G.; Miranda Murillo, J. P.; Mazzotta, G.; Slimani, S.; Alberti, S.; Lova, P.; Comoretto, D.; Steiner, U.; Peddis, D.; Dodero, A. Co-Assembly of Block Copolymers and Cobalt Ferrite Nanoparticles for Magnetic Material Design. *Chem. Mater.* **2025**, 37 (14), 5406–5416.

3. Iseli, R.; Abdelrahman, D.; Kilchoer, C.; Abdollahi, S. N.; Kainz, T. A.; Quddus, R.; Gu, Y.; Wiesner, U.; Wilts, B. D.; Vogler-Neuling, V. V.; Steiner, U.; Gunkel, I. Macroscopic Order in Block Copolymer Gyroid Films by Solvent Evaporation Annealing. *Polymer* **2025**, 335, 128676.

4. Schumacher, C.; Abdennadher, B.; Steiner, U.; Saba, M. Termination-Driven Control over Bound States in the Continuum Q-Factors and Frequencies in Plasmonic Double Net Metamaterials. *ACS Photonics* **2025**, 12 (9), 5009–5016.

5. Bertucci, S.; Schobinger, R.; Mummolo, L.; Schwarz, N.; Lova, P.; Weder, C.; Comoretto, D.; Steiner, U.; Di Stasio, F.; Dodero, A. Tunable Photonic Paints via Block Copolymer Self-Assembly and Refractive Index Engineering. ACS Appl. *Polym. Mater.* **2025**, 7 (13), 8743–8754.

Breaking points

_ Making hidden mechanical processes visible

Supported by two newly awarded collaborative grants, researchers from the Adolphe Merkle Institute's Mechanoresponsive Materials group are developing imaging techniques designed to detect mechanical processes before they become macroscopically visible. An SNSF Project Funding grant with the University of Konstanz will support the detection of low-force molecular changes that precede polymer failure. At the same time, a bilateral ANR–SNSF award with the University of Bordeaux will enable the measurement of piconewton forces exerted by cells in complex biological environments.

Alongside these projects, the group is collaborating with researchers at EPFL to resolve highly localized molecular changes around small defects using super-resolution microscopy. Together, the three approaches target processes that conventional measurements may miss because the forces are extremely small, the molecular responses are subtle, or the changes occur on very small length scales.

"By the time a crack or another macroscopic change becomes visible, many important processes have already taken place," explains PI Prof. Jessica Clough. "We want to develop imaging methods that can access these earlier molecular responses and reveal where they occur with greater precision."

Existing molecular force probes, known as mechanophores, produce an optical signal when a particular bond breaks or rearranges under force. Although effective for locating damage, they generally indicate that a specific mechanical threshold has been crossed. They provide less information about the lower-force molecular processes that precede permanent damage, such as conformational changes.

The project with Prof. Andreas Zumbusch at the University of Konstanz, therefore, aims to establish a new technique, mechano-Raman imaging. Raman spectroscopy detects vibrational signals that are highly sensitive to molecular structure. By designing probes whose Raman signals change when molecules bend or rotate under force, the researchers aim to obtain continuous, or "greyscale," information about mechanical deformation. The approach could reveal low-force processes that cannot be detected using conventional mechanophores and may provide an earlier warning of material failure.

A second project combines fluorescent mechanophores with SPIFFI, a recent super-resolution imaging approach pioneered in the Radenovic group at EPFL. SPIFFI, or spatial polarization-induced fluorescence fluctuation imaging, analyzes temporal fluorescence fluctuations to reconstruct images with enhanced spatial detail. When applied to mechanically responsive polymers, the technique can reveal how mechanophore activation is distributed across small cracks and other defects. It can also reveal the orientation of nearby polymer chains, while its high temporal resolution enables tracking changes in the local molecular environment as a crack develops.

The third research direction moves into mechanobiology, where biochemical and mechanical cues from the extracellular environment regulate cell behavior and contribute to diseases such as cancer. Yet the piconewton forces generated at cell–matrix contacts are difficult to measure in realistic tissues, as current methods typically rely on individual cells attached to flat glass surfaces. In collaboration with Dr. Chloé Grazon and Dr. Morgane Rosendale, the NanoForceX project aims to develop water-dispersible nanoparticles capable of detecting these forces within three-dimensional biological matrices. Two complementary designs, based on peptide force sensors and mechanophores, will target different ranges of extracellular tension. After initial testing in hydrogels, the sensors will be applied to multicellular cancer spheroids to explore whether they can map forces in a tissue-like environment.

"These projects bring together expertise that would not usually be found within a single discipline," says Clough. "By combining molecular design with vibrational imaging, super-resolution microscopy, nanoparticle science, and cell biology, we can begin to visualize mechanical processes that have previously remained inaccessible."

Hrishikesan Kalpakassery Pattam joined the Mechanoresponsive Materials group in 2023 as a PhD student. He earned his Master's degree in chemistry at the Indian Institute of Science Education and Research in Tirupati. His current research at AMI includes the SPIFFI project.

Mechanoresponsive Materials

Team

Prof. Jessica Clough, Yang Li, Hrishikesan Kalpakassery Pattam, Martina Martusciello, Iulia Scarlat

Key Publications

1. Li, Y.; Clough, J. M. Optical Force Monitoring in Polymeric Materials with a Coumarin-Based Mechanophore. *Angewandte Chemie International Edition* **2025**, 64 (41), e202513283.

2. Shimizu, S.; Clough, J. M.; Weder, C.; Sagara, Y. Hinge-Like Mechanochromic Mechanophores Based on [2.2]Paracyclophane. *Angewandte Chemie International Edition* **2025**, 64 (37), e202510114.

Hot build
_ Amour plating nanoprobes

The Adolphe Merkle Institute's BioNanomaterials group has developed an innovative method to help tiny tracers, used to study how nanoparticles behave in biological environments, resist chemical degradation, promising more reliable data for diagnostic nanomedicine.

To understand how nanoparticles behave in cells and tissues, researchers have relied on a tool known as a multimodal tracer. This probe emits a signal across two or more imaging techniques. Some of these nanoparticles, for example, are designed to fluoresce under laser light and reveal their structure when examined with an electron beam microscope. One of the most promising of these tracers is silica-coated gold nanoparticles, owing to their good biocompatibility, ease of synthesis, and versatility across different imaging techniques. But this approach has an unexpected weak point. One might assume the danger lies inside the cell, in the acidic compartments the particle eventually reaches. In fact, the shells hold up well there. The real damage happens earlier, outside the cell, in the protein- and ion-rich fluid the particle must cross on its way in. In that fluid, water slowly breaks apart the silica shell, and the surrounding pH, ions, and serum proteins all accelerate the process, causing the shell to fragment, leak its dye, and give unreliable signals. The researchers found that particles prepared for cellular imaging lost their shells entirely within 16 hours in this medium.

The AMI researchers turned to nature for a solution. Diatoms, tiny water-borne algae with intricate glass-like shells, don't build their durable structures in a single step. They first lay down a soft, gel-like silica framework that matures over time. The reactive groups on its surface condense into a dense, tightly bonded siloxane network, far more resistant to chemical attack than the fragile material it started as. The team set out to do the same with their nanoparticles. "Translating this principle to synthetic materials enabled us to create imaging probes that remain stable and reliable in complex biological environments," explains the AMI BioNanomaterials Co-Chair, Prof. Alke Petri-Fink.

The scientists adopted this framework-first approach, not unlike brickmaking. Make a brick from its constituent elements and then fire it in a kiln to give it strength and longevity. In the case of nanoparticles, the silica shell was hardened through calcination, in which the coated particles were heated to 800 degrees Celsius. This eliminated almost all of the reactive silanol groups that make the shell vulnerable to dissolution. Only then were the nanoparticles functionalized with fluorescent dyes, transforming them into finished nanoprobes.

Processing the particles this way brought a real advantage for imaging. With conventional probes, a bright signal can be misleading, since once the shell falls apart, the loose dye continues to glow even after the particle itself is gone. Because the stabilized shells stay whole, their fluorescence reliably marks a real, intact particle. This allowed the researchers to combine two views of the same particle, using its glow to quickly locate where particles are and its dense gold core to pinpoint them precisely under an electron microscope. In crowded regions, where fluorescence alone blurs particles together and can no longer distinguish them, the gold cores remained individually visible, maintaining accurate counts where light-based imaging fails.

Bio-inspired, matured structures for durable nanoprobes could be a new standard for nanomedicine research, says Fink. "These tracers finally allow us to follow nanoparticles inside cells with the certainty that what we see is real, an intact particle, not a signal left behind by one that has already fallen apart."

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Dr. Wang Sik Lee joined the BioNanomaterials group in 2023. He had previously worked at the Korea Research Institute of Bioscience and Biotechnology as a postdoctoral researcher after earning his PhD at the South Korean University of Science and Technology in 2020.

BioNanomaterials

Team

Prof. Alke Fink, Prof. Barbara Rothen-Rutishauser, Liliane Ackermann-Hirschi, Dr. Mauro Sousa de Almeida, Dr. Sandor Balog, Dr. Amélie Bazzoni, Elena Brinas, Dr. Anne-Marinette Cao, Shui Ling Chu, Luigi di Stolfo, Dr. Kata Dorbic, Roman Fortunatus, Regina Gomes, Gowsinth Gunasingam, Laetitia Haeni, Moritz Haeffner, Dr. Ruiwen He, Dr. Nathalie Jung, Darleen Koehn, Dr. Jorge Larios, Henry Lee, Yvan Ngon, Dr. Wang Sik Lee, Isidora Loncarevic, Luisa Path, Maria Porteiro, Barbara Rani Borges, Alain Rohrbasser, Dr. Patricia Taladriz, Dr. Dimitri Vanhecke

Key Publications

1. He, R.; Schaub, O.; Geers, C.; Moreno-Echeverri, A. M.; Gunasingam, G.; Balog, S.; Schultheiß, M.; Gutmann, B.; Krebs, T.; Petri-Fink, A.; Rothen-Rutishauser, B. An Online Measurement Approach to Monitor the Deposition of Diesel Exhaust Particles on Lung Cells In Vitro. *Environ. Sci. Technol.* **2025**, 59 (26), 13119–13130.

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3. Cao, A.-M.; Duruz, J.; de Almeida, M. S.; Vanhecke, D.; Alston, A. E.; Digigow, R.; Flühmann, B.; Petri-Fink, A.; Rothen-Rutishauser, B. Sulfide Silver Autometallography to Differentiate the Ultrastructural Localization of Iron-Carbohydrate Complexes inside Macrophages. *Sci Rep* **2025**, 15 (1), 43335.

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5. Fong, W.-K.; Vanhecke, D.; Hauser, D.; Balog, S.; Lemal, P.; Montasseri, S.; Rothen-Rutishauser, B.; Petri-Fink, A. Intermolecular Dynamics of Monoglyceride Mesophases with Their Biomacromolecular Corona. *Mol. Pharmaceutics* **2025**, 22 (7), 4221–4229.

In brief

Getting creative

AMI were the winners of the creativity prize of the University of Fribourg's #Ambassador Unifr competition.

Launched ahead of the university's Explora open day in September, the project aimed to reflect the diversity and richness of the university community, current and past, through the lens of social media. Participants were invited to pull on a uni hoodie and share pictures of themselves and their colleagues. Other prize categories included best Story, Institutional Outreach, and Community Engagement.

Hosting

In March, AMI hosted the BioAlps – Swiss Health Valley INSIDE event focusing on healthcare and materials research at the University of Fribourg.

The event included presentations from Institute professors and a visit of AMI's facilities. BioAlps offers networking and support opportunities through regional, national or international events to promote the region as a world-class center for life sciences innovation.

In April, Professor Joe Brader, head of the Soft Matter Theory group at the University of Fribourg, co-organized the two-day "New Frontiers in Classical Density Functional Theory" academic conference at AMI.

And in June, the Institute welcomed the 2nd Swiss Symposium on Materials Chemistry, organized by the Swiss Chemistry Society's Division of Materials Chemistry. The organizing committee was chaired by AMI Soft Matter Physics group leader Dr. Andrea Dodero.

Promotions

AMI group leaders advanced in the academic world through a series of appointments.

Georges Formon (Polymer Chemistry and Materials) was appointed Junior Professor at the Université Claude Bernard Lyon 1 (France).

Patricia Taladriz-Blanco was appointed Tenure-Track Distinguished Researcher at the University of A Coruña in Spain. At AMI, Taladriz Blanco was notably the leader of the working group focusing on toxicology for the European-funded ICPLASTIC COST Action. ICPLASTIC is a Europe-wide initiative that aims to develop and harmonize protocols for micro and nanoplastic sampling, detection, toxicity, and risk assessment.

Representing Europe

AMI's Chair of Polymer Chemistry and Materials, Prof. Christoph Weder, was elected as a European Zone Councilor of the American Chemical Society (ACS). The appointment follows recent reforms by ACS to introduce global "Zone Councilors," designed to give members out-

side the United States a stronger voice. As part of this new structure, Weder will represent the European region, contributing to discussions and decisions that shape the Society's scientific and strategic direction.

In his new role, Weder will serve as a link between European members and ACS leadership, helping ensure that regional perspectives and priorities are reflected in Council deliberations. The first cohort of Zone Councilors began their term in 2026. The ACS Council is structured as the deliberative assembly of the Society, serving as an advisory body.

Animal research

Switzerland has made remarkable progress in biomedical research while implementing ethical approaches through the 3Rs principles: Replacement, Reduction, and Refinement of animal experiments.

In the University of Fribourg's most recent report on animal experimentation, published in 2025, AMI's Co-Chair of BioNanomaterials, Prof. Barbara Rothen-Rutishauser, wrote that universities have important responsibilities in research, education, and innovation while maintaining public trust. This commitment extends beyond traditional animal research to developing innovative alternatives, ensuring that scientific advancement proceeds responsibly with sustained public support.

In Fribourg, the research community actively implements these principles through improved experimental design, enhanced animal welfare measures, and sophisticated in vitro and in silico models. This commitment requires transparency, cultural adaptation, and close collaboration with Swiss and international partners, such as the Swiss National Science Foundation's NRP 79 program on 3Rs, to advance New Approach Methodologies (NAMs) alongside responsible animal use. The BioNanomaterials group's research includes an important component focusing on 3R projects.

Special collection

The journal Soft Matter released a special collection of articles celebrating the 60th birthday and the achievements of AMI's Chair of Soft Matter Physics, Prof. Ullrich Steiner. Curated by some of his former group members (Profs. Stephan Guldin, Mathias Kolle, Silvia Vignolini, and Bodo Wilts), it highlights his impact on polymer physics, bio-inspired photonics, and functional nanostructures during a research career spanning nearly four decades.

Alumni

AMI alumna Dr. Corinne Jud Khan was appointed as the new head of Agroscope.

A member of AMI's Scientific Advisory Board, she took up her new position at Switzerland's federal research institute for agriculture and food science in March 2026, overseeing around 1,100 staff. Jud Khan has been a member of Agroscope's executive board since 2017, serving as head of the Methods Development and Analytics division. Prior to this role, she led feed analysis departments at Agroscope's predecessor institutions and served on various institutional leadership teams.

Her academic journey began with a biochemistry doctorate from the University of Fribourg in 2009, for which she received the prestigious Chorafas Prize. During her doctoral work, she researched circadian rhythms, focusing on "The influence of light on the circadian clock of mice and men". Following her PhD, Jud Khan spent three years at the Adolphe Merkle Institute working in the Soft Nanosciences and BioNanomaterials research groups, investigating structural properties of eye lens proteins and developing novel cell culture models.

Polymer Chemistry and Materials alum, José Berrocal (Institute of Chemical Research of Catalonia, Spain), was appointed as an ICREA Research Professor. ICREA appointments recognize scientific excellence and grant researchers the freedom to pursue long-term, high-impact research without teaching or administrative obligations. The positions are permanent and equivalent to tenured posts, with ICREA scientists expected to contribute actively to strengthening and advancing the Catalan research landscape. ICREA, the Catalan Institution for Research and Advanced Studies, is a foundation supported by the Catalan government.

Prof. Alessandro Ianiro (KU Leuven), a BioPhysics alum, received an ERC Starting Grant for the CHIMERA project, which combines key features of biological and synthetic membranes to create high-performance biomimetic systems. Biological membranes achieve exceptional selectivity and permeability through ultra-thin lipid layers with embedded proteins, while synthetic ones typically cannot deliver both. With €2.3 million over five years, CHIMERA aims to develop scalable, cost-effective membranes that improve energy-intensive separation processes, offering economic and environmental benefits.

Networking in Asia

Representatives of the Adolphe Merkle Institute, the Chair of BioPhysics, Prof. Michael Mayer, and the Head of Technology Transfer and Innovation, Dr. Ana Marques, travelled to South Korea in June for the 2025 Swiss-Korea Innovation Week organized by the Swiss embassy in Seoul. They were joined there by AMI alumni Prof. Alessandro Ianiro and Prof. José Berrocal, co-leaders of the INTEGRATE project together with Michael Mayer.

The INTEGRATE team presented its latest advances in energy-harvesting organs and novel actuating materials for next-generation artificial muscles at the Swiss-Korean Life Science Symposium. The research program, which recently concluded and was funded by the European Innovation Council and the Swiss Secretariat for Education, Research and Innovation (SERI).

Funding success

Soft Matter Physics group leader Dr. Viola Vogler-Neuling was awarded an Ambizione fellowship from the Swiss National Science Foundation (SNSF) — one of Switzerland's most competitive research grants.

Over the coming years, her team will investigate how nature creates some of its most dazzling colors and explore ways to reproduce them sustainably in the lab.

If successful, the research could lead to biodegradable photonic pigments inspired by nature, offering brilliant, long-lasting colors without toxic chemicals or fading. Such materials could be used in displays, optical devices, and many other technologies, while advancing our fundamental understanding of how nature creates long-lasting colors. The funding from the SNSF's Ambizione program is specifically designed to enhance the scientific profile of researchers from Switzerland and abroad and help them become scientifically independent early in their careers with a project of their own.

BioPhysics group leader Dr. Anasua Mukhopadhyay received a Young Investigator Award from the Novartis Foundation for Medical-Biological Research in April 2025, worth up to CHF 80,000. This grant is a funding instrument specifically targeting researchers at the very early stages of academic independence who are starting or continuing their first independent research project at a Swiss institute.

Pint of science 2025

The Pint of Science festival returned to Fribourg in May 2025 as part of a global event.

The local organizing team included AMI PhD students Carolina Pierucci and Iulia Scarlat. AMI postdoctoral researcher Dr. Manon Guivier was among the speakers, presenting how drawing inspiration from natural materials such as wood or leaves can lead to the creation of bio-based, high-performance, and more environmentally friendly "super" materials.

Pint of Science is an international science festival that takes place annually over the same three evenings. In Fribourg,presentations were in English, French, and German, and ranged from biology and medicine to literature, history, and law.

Award-winning

AMI's Co-Chair of BioNanomaterials, Prof. Barbara Rothen-Rutishauser was recognized in 2025 with the International Society for Aerosols in Medicine (ISAM) Juraj Ferin Award at the organization's congress in Washington, DC. It is given to society members who have made outstanding contributions to ISAM.

The award also highlights excellence in medicinal aerosols and inhalable materials, as well as commitment to advancing the ISAM's mission and goals. Rothen-Rutishauser is a past President of the society.

Falling Walls Lab

As part of its outreach activities, the National Center of Competence in Research Bio-Inspired Materials, based at AMI, organized the third edition of the Falling Walls Lab (FWL) Fribourg pitching competition in July 2025.

Nick Zahnd, a PhD student in the AMI Polymer Chemistry and Materials group was the winner with his pitch focused on Breaking the Wall of Powering Biomedical Devices. The runner-up was PhD student Oindrila Mondal from the same group, with her pitch on Breaking the Wall of Everlasting Polymers, ahead of Eva Baur, a doctoral student from EPFL who spoke about Breaking the Wall of Printing Soft Materials.

The FWL is organized as part of a global pitch competition that provides a stage for an interdisciplinary pool of students and early-career professionals to present their breakthrough ideas in just three minutes. In 2025, more than 2,750 applicants participated in 82 Falling Walls Labs across 60 countries, vying for a place in the global final held in November at the Falling Walls Summit in Berlin.

Public health

AMI BioNanomaterials Co-Chair. Prof. Barbara Rothen-Rutishauser was appointed to the Public Health Cluster of the Swiss National Science Advice Network (SNSAN).

This cluster is tasked with identifying existing or emerging health risks and advising policymakers based on current scientific findings, with the aim of anticipating public health crises. It acts as a permanent interface between science and politics. Rothen-Rutishauser, the sole representative of the University of Fribourg, is part of the sub-cluster Environmental health risks. Set up at the Swiss government's instigation following the Covid pandemic, the SNSAN's role is to quickly mobilize independent, interdisciplinary scientific expertise to advise policymakers and authorities on crisis management and preparedness.

AMI Cup

The now-traditional AMI Cup was won for the first time by the BioNanomaterials group. Organized by the Polymer Chemistry and Materials and Mechanoresponsive Materials groups, the annual event served up original physical and intellectual challenges, as well as genuine teamship.

Prizes

The Soft Matter Physics PhD students shone in 2025.

René Iseli was the winner of the best poster prize at the Swiss Nanoconvention held in Brugg, canton Aargau. Iseli also finished as the runner-up in the Science Shots competition organized by the Science et Cité foundation. Science Shots is a competition for early-career researchers who

want to offer exciting insights into their scientific work. He not only explained the science behind some of his work (bio-inspired materials) in 90 seconds, but also brought his illustration talents to the fore. His colleague Nicolas Bruder earned himself the third prize for his poster at the 17th International Conference on Nanomaterials – Research and Applications in Brno, Czechia.

Published in Nature

Soft Matter Physics PhD student René Iseli was the co-author of an article in the prestigious journal Nature, which sheds new light on the intricate relationship between climate change, wildfires, and atmospheric methane levels.

Iseli worked on the project, which analyzed air bubbles trapped in Antarctic ice cores, as part of his Master's thesis at the University of Bern. The study suggests that abrupt increases in methane from biomass burning coincided with two types of climate events that occurred during the last ice age.

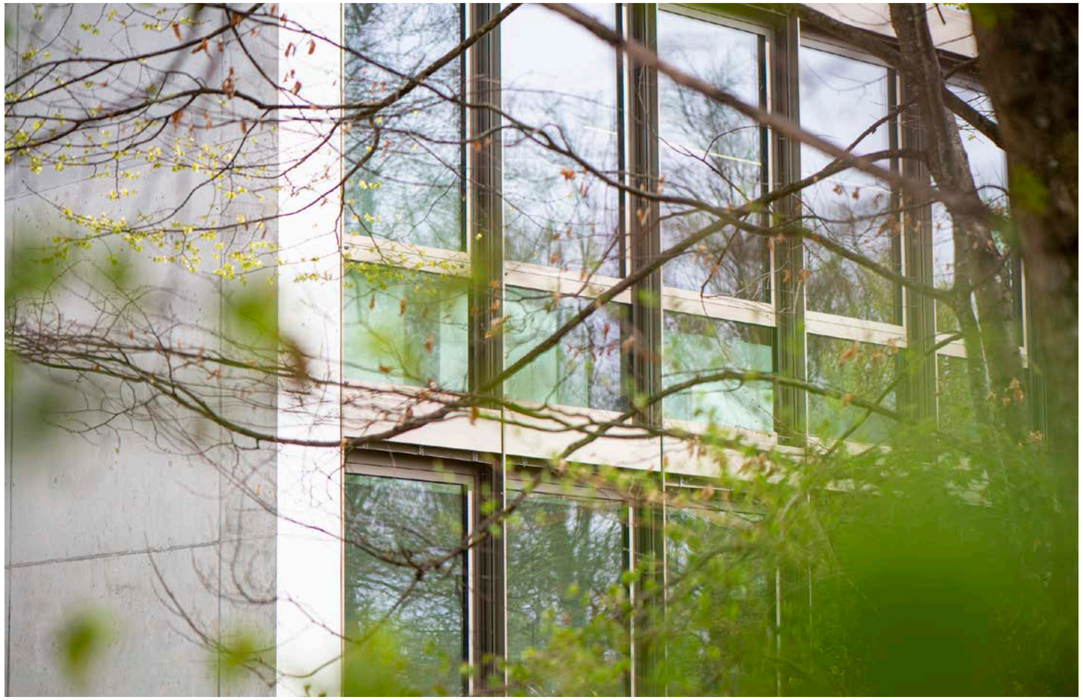
The researchers observed sudden spikes in specific methane isotopes. The results also point to a strong connection between these climate events and massive increases in wildfires, particularly in tropical regions. According to the researchers, this study, which used sophisticated computer models to interpret the ice core data, not only enhances our understanding of Earth's past climate but also provides valuable insights into the complex interactions between climate change, fire patterns, and the global carbon cycle.

37

__ Finance & Organization

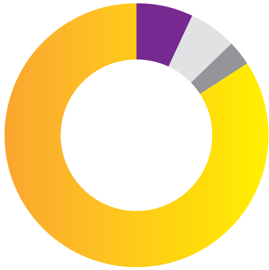
Finance

_ Cost structure at AMI



The Adolphe Merkle Institute's overall expenditures rose slightly in 2025 to CHF 9.74 million. 84% of this sum was spent on research, while an additional 6% was invested in research equipment. Around 3% of the budget supported valorization activities such as technology transfer, communication, and marketing, with another 7% covering administration costs.

Overall expenses 2025
CHF 9.74 million

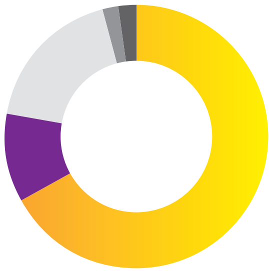


Research / 84%
Administration / 7%
Research equipment / 6%
Valorization / 3%

Funding sources of overall expenses 2025

Adolphe Merkle Foundation / 28%
Grants / 48%
University of Fribourg / 23%
Industry / 1%

Third-party funding 2025
CHF 4.82 million



SNSF / 67%
EU / 11%
Other sources / 18%
Innosuisse / 2%
Industry / 2%

Organization

In late 2007, Adolphe Merkle set up the Adolphe Merkle Foundation and donated CHF 100 million to support the University of Fribourg. The donation has been used primarily to establish the Adolphe Merkle Institute.

The Institute Council plays an important role in controlling and supervising the development of the Institute at the University of Fribourg's science faculty. It guarantees optimal communication and coordination between the University and the Foundation and helps the Institute to fulfill its mission and to smoothly integrate into the university.

The Scientific Advisory Board is an independent team of experts with backgrounds and expertise in fields that are relevant for AMI. It provides an external view to help position the institute in its national and international environment.

The Executive Board oversees daily operations at AMI and meets once a week. All AMI professors are members of this management body. They are responsible for ensuring that the strategy approved by the Institute Council is implemented.

The Administration team provides support in many aspects of the Institute's daily work and acts as an interface between the University of Fribourg and AMI.

Foundation Board

Members

Peter Huber (President)
Administrator, Sublevo AG, Kloten, Switzerland

Jean-Pierre Siggen
Canton Fribourg Finance Minister

Chantal Robin
Former Director, Fribourg Chamber of Commerce and Industry

Prof. Rolf Mülhaupt
Former Managing Director Freiburg Center of Interactive Materials and Bioinspired Technologies

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

André Broye (Managing Director)

Institute Council

Members

Prof. Katharina Fromm (President)
Rector of the University of Fribourg, Professor at the Faculty of Science and Medicine, University of Fribourg

Peter Huber (Vice-president)
Administrator, Sublevo AG, Kloten, Switzerland

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43
_ Graduates & Alumni

PhDs and Masters

Our new doctors

Henry Lee
(BioNanomaterials)
"Macrophage-nanoparticle interactions across the spectrum of polarization, senescence, and imaging"

Viola Bauernfeind
(Soft Matter Physics)
"Exploring the Role of Disorder in Photonic Architectures in Longhorn Beetles"

Cristina Prado
(Soft Matter Physics)
"Improving Copolymer-based Electrolytes for Lithium Batteries – Cellulose Reinforcement and Surface Engineering"

Xueqian Hu
(Polymer Chemistry and Materials)
"Nanostructured Polymers for Energy Harvesting and Conversion"

Master's thesis

Vincent Glauser
(Soft Matter Physics)
"Computer-generated disordered networks for photonic band gaps"

Alumni

People who left AMI in 2025

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Wachara Chanakul
BioPhysics

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