2020 _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 the domain of soft nanomaterials.

We owe our existence to Dr. Adolphe Merkle, a successful local entrepreneur, who established the Adolphe Merkle Foundation with the goal of strengthening research and teaching at the University of Fribourg. His CHF 100 million endowment constitutes one of the most important private donations in Switzerland in favor of academic research.

Founded in 2008, AMI is in many aspects unique in the landscape of Switzerland's research institutions. 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, more generally, improve the quality of life.

Our researchers are currently organized in four research groups, which offer complementary expertise and interests in strategically important areas: BioNanomaterials, Polymer Chemistry & Materials, Soft Matter Physics, and Biophysics. 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 our world-class research facilities make AMI a desirable destination for master's and PhD students, postdocs, and senior researchers.

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Professor Christoph Weder

I am happy to present to you the Adolphe Merkle Institute's annual report 2020, in which we share, as every year, our most important activities, accomplishments, and developments.

Of course, the Covid-19 pandemic, for which AMI was as prepared as anyone, had a considerable influence on the institute. The restrictions that the virus imposed, called virtually every aspect of our activities into question, and forced us to re-think where, when, and how we work. Permit me to use this platform to express my sincere gratitude and appreciation to the entire AMI team for coping with the circumstances in the best possible ways and doing a fantastic job to not only maintain our operations, but making the last year one of the most productive yet.

Thus, it is not the pandemic, but instead our research endeavors and successes that take the center stage of this annual report. The topics that we highlight this year include the application of silica nanoparticles to stimulate the immune response of plants to pathogens. This elegant approach appears to be a promising way to reduce the use of synthetic fertilizers and pesticides, which is a topic of considerable societal interest. We also report on the design of muscle-imitating polymer actuators for soft robotics applications, a new technique to image proteins that are responsible for Alzheimer's Disease, and creating metamaterials for sensing systems. These research stories highlight projects in which we have made particular achievements. They also reflect the diversity of topics that our now almost hundred researchers work on.

We also present two independent projects of junior researchers that address pressing environmental issues. Our newly minted Assistant Professor Jovana Milic is developing the scientific basis for more sustainable photovoltaic technologies, while postdoctoral researcher Roman Lehner set up the Sail and Explore association to collect samples from the oceans and to monitor the distribution of microplastic pollution.

You will find more coverage of other achievements of junior researchers in our "In Brief" section, together with many other highlights from the last year that range from awards to sparking ideas and from slime to 3D printing.

Translating research outcomes into practical useful processes or new technologies is an essential part of our institute's mission. In this year's report we present the status of four start-up ventures that are at different stages of the spin-off process.

We hope you enjoy the lecture of this report and thank you for your interest in our institute, our team, and our activities.

Christoph Weder
AMI Director and Professor for Polymer Chemistry & Materials

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Pursuing excellence

Pandemic

_ A year (or more) to remember

Lab work resumed with appropriate safety measures in place

The Adolphe Merkle Institute, like other research centers, has been forced to adapt in the wake of the coronavirus pandemic. Despite the difficulties, AMI managed though to keep its staff safe and pursue its scientific goals.

March 16, 2020: the coronavirus pandemic forces the Swiss government to partially shut down the country, just as its neighbors have done. The impact on the University of Fribourg and the Adolphe Merkle Institute was immediate. Classes were cancelled throughout the university, labs were closed, and access to all university buildings was prohibited. All members of the institute were forced to stay at home, from where they worked for the better part of the next three months. Professors and lecturers scrambled to move their classes online, students switched to remote learning, often alone, and researchers found themselves out of their labs.

While the closure initially was supposed to last six weeks, after a month, all in-person courses were cancelled for the rest of semester. It was not until mid-May that researchers were allowed to return to their labs under certain conditions, but working from home remained the norm for everyone not carrying out experiments. By the beginning of summer, there was some return to normalcy, but the respite was short-lived. The second wave of the coronavirus struck Switzerland in October, and on the ninth of that month, it was a return to home office for everyone at AMI for at least a week after two members tested positive for the virus. A few weeks later, in-presence teaching was once again suspended, and remote work became the standard for many. The working conditions only started to normalize towards the end of spring 2021, and at the time of printing of this report, it is far from clear what the rest of the year will bring.

For AMI's leadership, like everyone else, the situation was beyond normal. The multiple shutdowns put a number of issues on the table. "Our first concern was that everyone was safe and healthy," explains Prof. Michael Mayer, head of AMI's health and safety committee. "This was especially important as many of our institute members don't have family or a network they can rely on in Switzerland. And leaving to go home wasn't necessarily an option as we didn't know how long the situation was going to last or if people could even travel." Next came the question how to resume operations in a safe and efficient manner.

Especially PhD students and postdoctoral researchers became increasingly nervous after being locked out of the laboratories. While the home-office setting initially provided some quality time for writing and planning, those approaching the ends of their limited-term appointments were eager to get back to the lab, especially when critical experiments were missing. Thus, when the lockdown was partially lifted, it was important to allow researchers back into the lab.

"We quickly developed a comprehensive safety concept that allowed all of our researchers to access their bench space in a timely and safe manner," said AMI Director Prof. Christoph Weder. "We had to ensure that the practical aspects of work were possible while maintaining the health guidelines set out by the university." This meant that working from home remained compulsory for everyone not involved in laboratory work, while AMI professors all spent one day a week at the institute to provide cover in case of an emergency. For Mayer, the measures implemented at AMI by the institute's executive board have been successful. "We saw no cases of community transmission within the institute, which indicates that our safety-first approach was absolutely successful" he added.

In spite of all of these restrictions, AMI researchers remained highly productive says Weder. "All our performance indicators were on par with the previous year, and we are really proud of what our team has achieved, given the circumstances. Everyone really made the most of it".

Social interactions, however took a massive hit, with many of the traditions banned by the health guidelines. PhD defenses became virtual, without the joyful aperitifs that normally follow a successful exam. Friday cake time and summer barbecues were scratched during the pandemic, and the traditional AMI Christmas party became an online event. "In the bigger scheme of things, these might seem like minor points, but part of what makes the institute successful is the sense of community that our members develop," adds Weder. "Our researchers come from all over the world, and are often far away from their families. For many of them, interactions with other team members and the friendships that ensue become an essential part of their lives. Making new friends via a Zoom call is kind of difficult."

"All our performance indicators were on par with the previous year, and we are really proud of what our team has achieved, given the circumstances."
Prof. Christoph Weder, AMI Director

In-person interactions with international colleagues and national collaborators were also off the program due to the pandemic, while seminars, workshops, and conferences were either cancelled or held online. Weder and Mayer agree that some of the forced changes are likely here to stay because "the community certainly discovered some of the benefits of the formats" that were developed in a hurry. However, they are also worried about the negative consequences that this radical change has brought to the "Covid" generation of PhD students and postdocs, who miss many opportunities for building professional networks in a critical phase of their careers.

With the arrival of coronavirus variants, the new normal is still not clear, and traditional working models may no longer apply. "Research itself will not fundamentally change. Work still needs to be done in the lab, scientists need to come together to discuss and debate their findings, and new collaborations remain vital to make science progress, but various ways to do things that the pandemic forced upon us are likely here to stay" explains Weder.

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NATIONALITIES

ARE PRESENT AT AMI, WITH STAFF COMING FROM EVERY CONTINENT.

5

PROFESSORS

SPECIALIZING IN POLYMER SCIENCE, MATERIALS, PHYSICS, CHEMISTRY, AND BIOLOGY.

58%

OF ALL RESEARCH EXPENDITURES

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

MORE THAN

7000

CITATIONS

OF AMI PUBLICATIONS IN SCIENTIFIC LITERATURE IN 2020

3

PROJECTS

FINANCED BY INDUSTRIAL PARTNERS IN 2020.

105

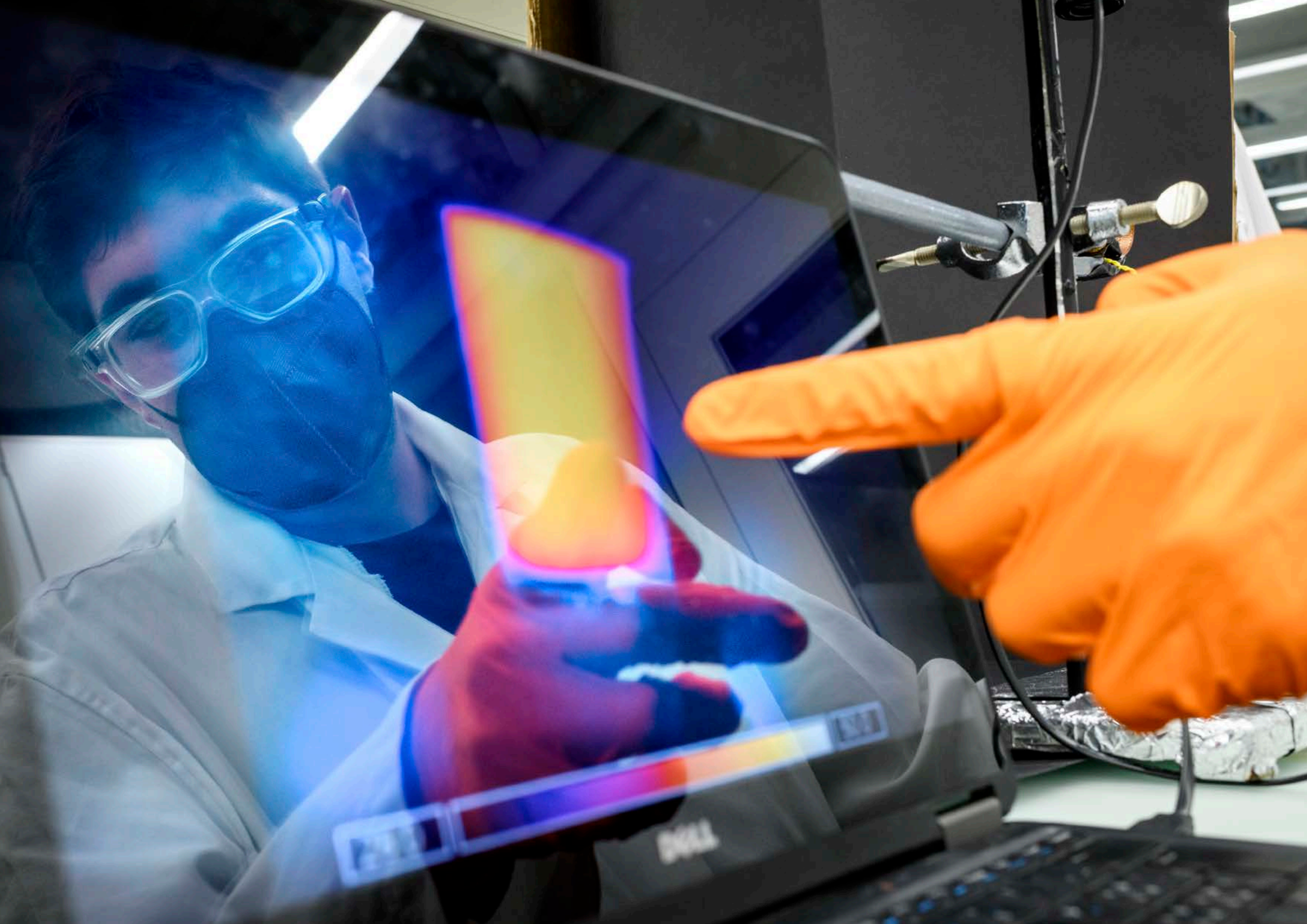
SCIENTIFIC PUBLICATIONS

IN TOP-RANKED JOURNALS SUCH AS NATURE NANOTECHNOLOGY, SMALL, ACS NANO, ANGEWANDTE CHEMIE INTERNATIONAL, ADVANCED MATERIALS, NANO-SCALE, ADVANCED FUNCTIONAL MATERIALS, ANALYTICAL CHEM-ISTRY. ECOLOGY AND EVOLUTION, ACS OMEGA, POLYMERS, PAR-TICLE AND FIBRE TOXICOLOGY, ELIFE, PLOS.

300

ALUMNI

INCLUDING POSTDOCTORAL RESEARCHERS, PHD STUDENTS AND INTERNS.


DELL

Innovation

_ Converting research into new technologies

Translating research outcomes into practical useful processes or new technologies has always been part of the Adolphe Merkle Institute's DNA. After more than a decade since its foundation, the Institute now has a critical mass of projects that have matured to the point where the translation into practical applications appears feasible or has already started.

The application of AMI's research, or the sharing of its knowledge for application projects, takes multiple forms. This can be research collaborations such as the one on shape memory polymers completed by the Polymer Chemistry & Materials group with Swiss hearing care company Sonova, or measurements for external clients that rely on AMI's analytical infrastructure and the related expertise.

However, the most visible marker of the development of research applications is the creation of new businesses through startups of various forms. Over the past five years, several projects have matured to the point where companies are founded and projects become concrete. Here we present four of those developments.

NanoLockin

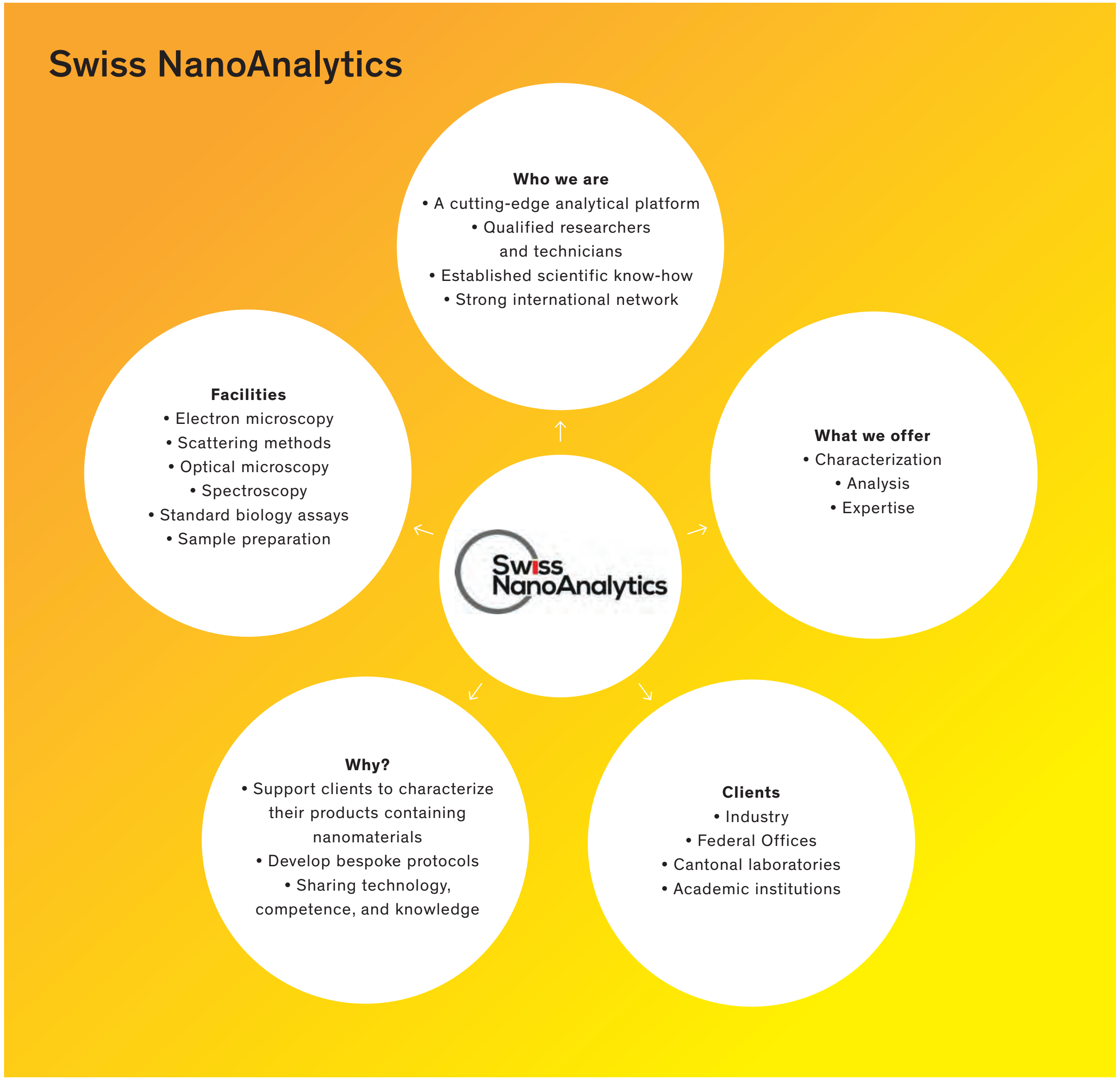
NanoLockin is AMI's first startup. Since its launch in 2018, it has further improved a device based on the concept of lock-in thermography – a technique originally created for the quality control of aircraft parts – and developed by the AMI BioNanomaterials group in collaboration with the Zurich University of Applied Sciences. NanoLockin's technology allows users to detect metallic nanoparticles, carbon-based materials, and selected metal-oxides. The Calorsito VIS-NIR instrument can help analyze nanoparticles in liquids and solids over large sample areas. This allows, for example, measurements in biological and physiological fluids, cells, tissue (skin, biopsies), consumer products (juice, packaging), and composite materials. Since its launch, NanoLockin's capacity for innovation has been recognized by various grants, including BRIDGE funding from Innosuisse, the Swiss innovation agency, and the Swiss National Science Foundation; the canton Fribourg Innovation Prize in 2018; and an interest-free loan from Fribourg Seed Capital.

Swiss NanoAnalytics

Launched in early 2020, Swiss NanoAnalytics (SNA) is a new platform that so far has been based at the AMI, and was developed by the BioNanomaterials group of Professors Alke Fink and Barbara Rothen-Rutishauser. SNA offers high quality services for the analysis of nanomaterials. These include the characterization of the physicochemical properties of nanomaterials, isolation and analysis of the occurrence of nanomaterials in food products and cosmetics, testing the stability and size of nanomedicines in biological fluids such as blood serum, and testing material composites used in electronics or construction materials. The platform makes full use of AMI's analytical facilities, with access to a number of nanomaterial characterization techniques, including electron and optical microscopes, light-scattering machines, and spectrometers, among others. The aggregation of these different techniques provides a complete analysis of nanomaterials for academia and industry. The platform's clients also include federal agencies and cantonal laboratories.

Hemolytics

Hemolytics is a startup venture in which members of the former AMI Macromolecular Chemistry group led by Professor Nico Bruns are developing a new malaria diagnostics test. The project team has devised a simple screening kit for asymptomatic carriers of the disease. Hemolytics aims to demonstrate the importance of asymptomatic screening in the arsenal of tools to fight malaria, which will help the World Health Organization to officially endorse asymptomatic screening in their global strategy for malaria eradication. The technology behind the kit has recently been patented. Over the past five years, the project has been the recipient



of BRIDGE funding as well as a grant from the Gebert Rüf Foundation.

Nanofertilizer

The most recent AMI project that is moving towards a practical application is the nanofertilizer project led by Dr. Fabienne Schwab (BioNanomaterials group). This activity resulted from the discovery that specific silica nanoparticles can act as a degradable, and highly efficient treatment against some plant pathogens (see research story page 26). Schwab and her colleagues have patented nanoparticle technology for the targeted delivery of active ingredients and to stimulate plant resistance. The project has moved into a new stage with the financial support of Innosuisse. Field trials and upscaling of nanoparticle production are now underway in collaboration with the University of Applied Sciences and Arts Western Switzerland – Fribourg and the Bern University of Applied Sciences.

Data

- Companies with which AMI technology transfer signed at least one contract in 2020 (including non-disclosure agreements, research collaborations, and intellectual property agreements): 21
- Active research projects financed by industrial partners in 2020: 3
- Active research projects financed by Innosuisse in 2020: 3
- Active clients of Swiss NanoAnalytics in 2020: 8

All at sea

_ Discovering microplastics in the environment

Roman Lehner launched his first expeditions in 2018

Plastic pollution has become a pressing issue, as unfathomable amounts of plastic debris have been and continue to be released into the environment. While plastic waste can be found in practically every nook and cranny of the earth, most of it ends up in the oceans. AMI researchers are contributing to the investigation how severe the spread has become.

It's become a habit. Every few months, AMI alumnus Dr. Roman Lehner heads out to sea in his spare time looking for plastic samples. Each time the special manta trawl goes in the water alongside his chartered yacht, he's almost sure to find something in the net. "Our oceans are highly polluted with plastic litter," he says. "The likelihood of not finding any plastic is almost zero, but depending where you search, there can be huge differences in the amounts you turn up." According to the International Union for Conservation of Nature, at least eight million tons of plastic end up in our oceans every year, and make up 80% of all marine debris. Often the particles are tiny and barely visible, because sunlight, water, and constant motion eventually transform larger objects into microplastics - small fragments with dimensions of less than 5 mm. The fragments are remnants of fishing lines, polystyrene foam, packaging materials, and other plastic objects that enter the seas. An estimated 70 per cent of all the plastic pollution sediments on the sea floor because it does not float, making it a case of out of sight, out of mind.

The non-profit association Lehner set up while working at AMI, Sail and Explore, conducts sailing expeditions with citizen scientists to collect data, and works with local researchers onboard, as well as with several marine protection organizations. So far, samples have been collected in the Mediterranean, off the Azores in the Atlantic, and most recently on the Australian eastern seaboard in collaboration with the University of Newcastle. The aims of Lehner's expeditions are to improve the understanding of the type, quantity and composition of ocean plastics, to test new sampling methods, and to develop approaches to help understand the impact of this pollution on life cycles and food chains.

"The Mediterranean Sea, for example, is one the most polluted waters in the world, at least as far as microplastics are concerned," Lehner explains. "We found, on average, more than 250'000 plastic particles per square kilometer there, while during our latest expedition around the Whitsunday Islands in Queensland Australia, we barely found any microplastics at all, which is a good sign!" According to the former BioNanomaterials group researcher, this highlights the need for more data collection. Often, scientists collecting water samples carry out a single expedition in a specific location, so that their data only serve as a snapshot in space and time. To understand trends, and monitor changes in microplastic pollution over time, Lehner is collaborating for example with scientists in the Azores, a remote group of islands located on the edge of the North Atlantic Subtropical Gyre, an important accumulation zone of microplastics in the open ocean.

"The best way to sensitize people to an environmental issue, and to implement change is by active engagement with the problem."
Dr. Roman Lehner,
AMI BioNanomaterials alumnus

"My research project at AMI supported the overarching goal to connect environmental issues and human health. The expeditions allowed me to collect relevant environmental samples, which I used to investigate the possible toxicological effects of microplastics on human immune cells," says Lehner. "The use and testing of environmental relevant samples are critically important to this research, for example to develop an understanding if the presence of microplastics at a specific size range in our food and water is a cause of concern." This work was funded by a Spark grant from the Swiss National Science Foundation. These grants are aimed at funding ideas of high originality.

So far, there is little existing data about the possible adverse effects of microplastics on human health, although this does include the results of a study published in April 2020 by the BioNanomaterials group. The study involved the development of a novel human intestinal model to study the immune responses upon exposure to microplastics.

Through his work, Lehner's hopes to raise awareness of the extent of the problem. "The best way to sensitize people to an environmental issue, and to implement change is by active engagement with the problem," he explains. "By taking part in a scientific expedition, people get hands-on knowledge, as well as first-hand information from other researchers working on the topic in the affected zones."

No need to head to the ends of the of the earth though to find out how microplastics are affecting water. Lehner is now overseeing a project to investigate the impact of the pollution in Switzerland's lakes and rivers, notably in high alpine regions. Proof that the problem is indeed truly global.

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Lehner, R.; Weder, C.; Petri-Fink, A.; Rothen-Rutishauser, B. Emergence of Nanoplastic in the Environment and Possible Impact on Human Health. *Environ. Sci. Technol.* **2019**, 53 (4), 1748–1765.

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ACTIVE RESEARCH PROJECTS

IN FIELDS SUCH AS SHAPE-MEMORY POLYMERS, BIO-INSPIRED MATERIALS, MICRO-PLASTICS, AGROCHEMICALS, SOLAR CELLS, MALARIA DIAGNOSTICS, DETECTION OF NANOPARTICLES, NANO-PORE FABRICATION, SINGLE-MOLECULE DETECTION.

CHF 9.9 mio

SPENT IN 2020

RESEARCH EXPENDITURES ROSE FROM CHF 8.4 MILLION IN 2019 TO CHF 8.9 MILLION.

45%

OF STAFF AT AMI ARE WOMEN

21

SEMINARS

GIVEN BY EXTERNAL RESEAR-CHERS, AND AMI STUDENTS (13 ONLINE OR HYBRID).

113

PEOPLE

WORKED AT AMI AT THE END OF 2020 INCLUDING PHD STUDENTS, POSTDOCTORAL RESEARCHERS, PROFESSORS, SUPPORT STAFF, AND INTERNS.

43%

OF AMI STAFF

ARE DOCTORAL STUDENTS.

Rising star
_ Leadership and greener photovoltaics

Jovana Milic is focusing her research on “smart” energy materials inspired by nature

The Adolphe Merkle Institute’s newest Professor, Jovana Milic, is looking to develop the scientific basis for greener photovoltaic technologies and is already well on track to become an academic leader and mentor for a new generation of scientists.

Dr. Milic, who joined AMI in September 2020 as a group leader in the Soft Matter Physics group, was awarded a PRIMA grant last year by the Swiss National Science Foundation (SNSF). These grants are awarded to excellent female researchers who show high potential for obtaining a professorship. Milic was recently appointed Assistant Professor by the University of Fribourg for the duration of her grant, allowing her to serve as the official supervisor for her graduate students and to take on teaching and institutional responsibilities at the University. She will also be able to pursue other collaborative projects as principal investigator, which will further benefit her own research progress and her development as an independent scholar.

With support through her PRIMA grant, Milic and her team are investigating hybrid materials that mimic control strategies found in nature, such as those involved in photosynthesis. Her goal is to incorporate larger elements of organic molecules in perovskites to create layered structures that resist environmental degradation, and develop materials that can purposely modify their structure to control their properties under operational conditions.

Explain what you mean with “greener photovoltaics”.

Jovana Milic: My research is centered around the development of (supra)molecular materials for renewable energy conversion, with a particular focus on photovoltaics. Solar energy has the potential to meet our increasing societal energy demands, while contributing to ending our reliance on fossil fuels. However, more innovation is needed to make these technologies truly sustainable and well-accepted in our society. This requires a continuous interdisciplinary effort at the interface of chemistry, physics, material science, and engineering, which is at the core of my scientific interests.

Perovskites solar cells are known for their lack of stability – aren’t you adding an additional layer of difficulty too early by going greener?

Even though hybrid perovskites have emerged as one of the leading photovoltaic materials, they feature instabilities that hamper their application. My research contributes to addressing these challenges by relying on an approach that mimics some of the strategies for controlling material functions found in nature. Besides enhancing stability without compromising performance, this approach also offers a pathway towards more sustainable technologies, for instance by reducing the environmental impact of lead-based perovskites. Despite their undeniable complexity, such challenges offer an intriguing platform regardless of potential applications, and I believe that they need to be addressed simultaneously, as both the instability and the environmental impact of hybrid perovskites are pressing issues.

Do you see yourself expanding your activities in other directions?

My primary research interests are in the domain of the development of smart materials that can adapt to a variety of operating conditions, and hybrid photovoltaics offer a unique platform to explore some of these strategies. This is particularly relevant in the ongoing efforts to develop smart self-sustained devices, such as in the Internet of Things (IoT) or wearable device applications. However, smart materials are not just relevant to energy harvesting and storage technologies. For instance, the main challenges related to hybrid perovskite instability stem from ionic motion during device operation, which may be detrimental in photovoltaics – yet it can be very beneficial in the development of innovative memory elements. In that regard, understanding and resolving some of the challenges related to the behavior of these mixed ionic-electronic semiconductors offers perspectives that are likely to reach beyond our current research.

What are your academic and personal goals as a researcher?

My objective as a scientist and academic is to advance knowledge and understanding through research efforts and collaboration, while raising and supporting a new generation of scientists and professionals with diverse perspectives who are empowered to pursue their own visions and goals. I believe that we can collectively address many pressing contemporary challenges by collaborating across disciplines and improving academic culture. With that in mind, apart from research and extensive collaboration, I am also invested in science outreach and policy, as I consider that it is my responsibility as a scientist to not only advance but also share knowledge and understanding towards the betterment of our society globally.

You are the recipient of PRIMA grant from the Swiss National Science Foundation – how do you think this will shape your career?

I am very honored to be one of the SNSF PRIMA Fellows, as this program recognizes exceptional female researchers with the prospect of obtaining a professorship in Switzerland, which is one of my academic goals. Moreover, apart from generous research funding that enabled me to pursue my research vision and start an independent academic career, the program is focused on advanced leadership, which can play a critical role in shaping my career as a scientist, academic, and leader.

The PRIMA grant is specifically aimed at female researchers. Do you feel that these types of awards are necessary and why?

I strongly believe that such programs are necessary to advance the careers of female academics, and to address the incredible gender inequalities in academia, which require more drastic measures to improve the culture and increase much-needed diversity. Apart from investing in female academics, the PRIMA program recognizes their non-linear career developments, and provides advanced leadership training that empowers female leaders in shaping academic culture in Switzerland and beyond. So this program sets a good example, although more is needed to overcome gender inequalities globally.

Besides your research, you also spend time actively connecting with young researchers via different initiatives and social media. What benefits do you get from this type of activity?

I am very invested in science outreach and policy, particularly through the activities of the European Young Chemists' Network (EYCN) and the International Younger Chemists Network (IYCN), as well as Swiss Young Chemists' Society. I have been a Board Member and Networks Team Leader at the EYCN, as well as Governance Team Member at the IYCN, and I have contributed to a number of activities and partnerships with academic, industrial, as well as governmental bodies, connecting and supporting young scientists globally. These involvements have contributed to my development as a professional, and helped define my leadership style, while providing me with an extensive network of remarkable people with diverse backgrounds and perspectives, and a shared vision. I treasure these interactions and encourage everyone to get involved with these types of organizations.

Alumni

_ Making access to knowledge simpler

Mehdi Jorfi (right) co-founded Science Rehashed with Boston University neuroscientist Shen Ning

Science communication often serves the purpose of sharing research outcomes with the general public, sparking interest in science itself, or promote dialogue between the public, experts and decision-makers. But as Adolphe Merkle Institute alumnus Dr. Mehdi Jorfi shows with his Science Rehashed podcasts, it can also serve to share knowledge among scientists.

Jorfi completed his PhD in 2014 in Professor Christoph Weder's Polymer Chemistry & Materials group and received the University of Fribourg's Prize for the best experimental thesis in the Faculty of Mathematics and Natural Sciences for his work. He then undertook postdoctoral research in the United States at the Massachusetts Institute of Technology, before joining the Massachusetts General Hospital and Harvard Medical School, where he was appointed as a Faculty member in Neurology in 2019.

You have a successful academic career that certainly keeps you busy, so why did you start this science communication project in your spare time?

Mehdi Jorfi: In Iran, where I grew up, access to scientific resources is difficult. Scientific information should be universally accessible, but outside of high-income countries it can be very difficult to obtain. I experienced this first hand. Iran is an emerging country. Most scientific papers available there are outdated and are to be found in the dark recesses of libraries. During my master studies, my fellow students and I were supposed to pitch papers from the previous five years, but the most recent publications we could get our hands on were two decades old. After I moved abroad, former colleagues from back home would reach out to me to help them access papers. The big problem is that the best journals have high subscription rates. One paper alone can still cost you $50 to download, even if national and international funding agencies are promoting open access models to lower or eliminate the entry threshold.

> "We hope to be a central channel that scientists and the public can trust for recent discoveries."
> *Dr. Mehdi Jorfi, AMI Polymer Chemistry & Materials alumnus*

So why did you choose the podcast format to address this problem?

It was when I began listening to other podcasts that I realized we should talk with the main authors of papers to get at least their take home message and help people stay up-to-date. After speaking with one of my work colleagues, we decided to launch the Science Rehashed project. We realized afterwards there is another audience that could find our podcasts relevant – our own students who struggle to stay updated. Unlike their colleagues in emerging nations, most of them are overwhelmed by the sheer number of journals they can access. Our podcast provides information on some of the most recent discoveries in the field of life sciences without all the scientific jargon, which can be a hurdle to interdisciplinary exchanges. This is especially relevant because most innovation takes place in that interdisciplinary space.

How do you fulfil that ambition?

One of the great things we have at Science Rehashed is our multidisciplinary team. We have a large group of volunteer scientists who come from bioengineering, neuroscience, and biology. We also consult principal investigators and pioneers on what are the relevant recent publications. We are not trying to be all things to everyone, but we are striving in the longer term to be a go-to option for life sciences and bioengineering, which are where our core competences lie. We hope to be a central channel that scientists and the public can trust for recent discoveries. A scientist should be able get an overview for what's happening in bioengineering to treat afflictions such as Parkinson's and Alzheimer's diseases for example while being a non-specialist. And as we grow, we might reach out to other fields and other people.

And how do you try to stand out from the many other podcasts about science that are available?

If you look at the top ten podcasts related to science and similar to what we are doing, there is no real overlap between their work and ours. There is no one like us rehashing scientific papers besides journals focusing on their own content. We also provide fireside chats with pioneers to talk about their journey, which is a specific niche of ours. And we produce 360-degree perspectives on special topics, such as what we did on the coronavirus pandemic. We bring together bench scientists, politicians, healthcare staff, and we talk about the same problem from different angles. For Covid-19, we even talked to patients themselves.

How welcome has this "sideline" as a science communicator been as far as your peers and colleagues are concerned?

When we started out, we did not expect such positive feedback, especially from our community in Boston. Almost all of the pioneers we contact accept our invitations to dialogue. Local research groups have also welcomed our initiative, saying that it is necessary and that we should cultivate it. I think this is due in part to the fact that scientists recognize that there is a problem with publications, especially worldwide accessibility. This is however a structural problem. But there is nothing preventing scientists from rehashing those papers, and giving the take-home message without scientific jargon to researchers in other fields and the wider public.

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_Research at AMI

Bent out of shape
_ Responsive grippers for soft robotics

Researchers at the Adolphe Merkle Institute's Polymer Chemistry & Materials group have developed bio-inspired thermally activated actuators that could serve as grippers for soft robotics, picking up and releasing small objects.

Mechanically morphing materials, which can change their shape or alter their mechanical properties in response to a signal, are quite common in nature and enable essential functions, especially those requiring motion. Some of the best-known examples of this are pinecones and the Venus fly trap. The design of these materials is often based upon hierarchical structures that efficiently translate chemical or physico-chemical events from a molecular to a macroscopic level, allowing for substantial mechanical effects while relying on only minor or no compositional changes.

Over the past two decades, scientists have investigated the underlying natural operational principles of such materials, and integrated their findings in artificial materials destined for applications as varied as architecture and soft robotics. Polymeric bilayer bending actuators represent one straightforward and widely investigated approach for creating devices that translate external stimuli into motion. Actuators are typically responsible for moving and controlling a mechanism or system in machines. Inducing movement in these actuators relies on the dissimilar thermal expansion of two different materials, which causes the bilayers to bend upon being heated as the two layers are expanding at different rates. However, since thermal expansion coefficients of polymers are generally small, the efficiency of this process is very limited.

Graduate student Livius Muff and Professor Christoph Weder of the Polymer Chemistry & Materials group sought to overcome this problem by creating bilayer actuators with a thermoplastic polyurethane elastomer containing a crystallizable polyester segment. The domains formed by the polyester segment melt and crystallize in a reversible manner at temperatures of between 30 and 60 degrees Celsius. This reversible physical transition leads to a very large thermal expansion, and therefore actuation, in a well-defined temperature range. Importantly, the polymer as a whole does not become liquid, because the urethane hard segments guarantee both mechanical integrity and elastic behavior at temperatures where the polyester domains have melted.

To achieve electrically-driven actuation, the researchers embedded electrodes in their devices that serve as resistive heating elements. After applying an electrical signal of several volts, the actuators would bend in a few seconds. Returning to the initial shape required more time, because the polyester segments in the specific polymer that was used displayed slow crystallization. The AMI researchers say that faster response times should be possible by changing the type of polyester and improving the electrode design.

These actuators could be applied as part of a novel design for soft robotics with the addition of a thermally controlled supramolecular polymer adhesive "gripper." The researchers demonstrated that a small object could be picked up, moved, and released.

The project is part of the international consortium "Program for International Research and Education (PIRE): Bio-inspired Materials and Systems" that is jointly funded by the US and Swiss National Science Foundations and unites researchers at four American universities and AMI to work on bio-inspired materials and systems and their use in soft robotics.

Reference

Muff, L.; Weder, C.; Exploiting Phase Transitions in Polymer Bilayer Actuators; *Adv. Intel. Systems* **2020**, 2, 2000177.

Livius Muff is a PhD student in the Polymer Chemistry & Materials group. He joined AMI in 2018 as a member of the Bio-Inspired PIRE project after completing his Master's degree at Zurich's Federal Institute of Technology (ETHZ).

Polymer Chemistry & Materials

Team

Prof. Christoph Weder, Dr. José Berrocal, Véronique Buclin, Dr. Jessica Clough, Claudio Cappelletti, Gwendoline Delepierre, Dr. Visuta (Kan) Engkakul, Dr. James Hemmer, Anne-Cécile Ferahian, Diana Hohl, Dr. Sètuhn Jimaja, Patricia Johnson, Aris Kamtsikakis, Dr. Feyza Karasu Kiliç, Derek Kiebala, Marco Mareliati, Franziska Marx, Baptiste Monney, Dr. Guillaume Moriceau, Livius Muff, Ilaria Onori, Dr. Subhajit Pal, Chris Rader, Anita Roulin, Felipe Saenz, Dr. Philip Scholten, Dr. Stephen Schrettl, Hanna Traeger, Sandra Wohlhauser.

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2. Saenz, F.; Ronchi, A.; Mauri, M.; Vadrucci, R.; Meinardi, F.; Monguzzi, A.; Weder, C.; Nanostructured polymers enable stable and efficient low-power photon upconversion; *Adv. Funct. Mater.* **2020**, 2004495.

3. Neumann, L. N.; Gunkel, I.; Barron, A.; Oveisi, E.; Petzold, A.; Thurn-Albrecht, T.; Schrettl, S.; Weder, C.; Structure-property relationships of microphase separated metallosupramolecular polymers; *Macromolecules* **2020**, 53, 5068 – 5084.

4. Wohlhauser, S.; Kuhnt, T.; Meesorn, W.; Montero de Espinosa, L.; Zoppe, J.O.; Weder, C.; One-component nanocomposites based on polymer-grafted cellulose nanocrystals; *Macromolecules* **2020**, 53, 821 – 834.

5. Olaechea, L.M.; Montero de Espinosa, L.; Oveisi, E.; Balog, S.; Sutton, P.; Schrettl, S.; Weder, C.; Spatially Resolved Production of Platinum Nanoparticles in Metallosupramolecular Polymers; *J. Am. Chem. Soc.* **2020**, 142, 342 – 328.

Crop protection

_ Reducing pesticide use with nanoparticles

Silica nanoparticles could act as a highly efficient treatment against some plant pathogens without unwanted effects, a discovery that Adolphe Merkle Institute researchers and colleagues at other universities are now implementing in an application project.

One of the biggest challenges facing agriculture today is the extensive use of fertilizers and pesticides. With an increasing number of products being banned or considered dangerous for human and animal health, the need for substitutes is acute. One approach to solve this problem is to stimulate plants' own immune response to pathogen attacks. Silicic acid, which naturally occurs in the soil, is known to provoke such responses in plants and amorphous silica nanoparticles can release this substance in small amounts. Such nanoparticles are naturally present in many food crops such as for example cereals, and are also widely used in artificial form. Indeed, food grade silica (SiO2) has been used for decades in a variety of products to prevent clumping, for example in table salt and protein powders, and is often declared as E551.

With this in mind, the Fribourg-based researchers sought to create an environmentally safe nano-agrochemical for the targeted delivery of silicic acid and to stimulate plant defense. They synthesized silica nanoparticles with properties that are similar to those found in plants. To test their efficacy, they applied the nanoparticles on Arabidopsis thaliana (thale cress), a widely used plant model, infected with the bacterial pest *Pseudomonas syringae*, another model organism. The results showed that the nanoparticles can boost the plants' resistance against the bacteria in a dose-dependent manner by stimulating the defense hormone salicylic acid, which is also the active ingredient in aspirin. The researchers also investigated the interactions of the nanoparticles with plant leaves. They were able to show that nanoparticle uptake and action occurred exclusively through the leaf pores (stomata) that allow the plants to breathe. The nanoparticles did not distribute further in the plants, and the particles degrade without leaving a trace in the presence of water, an important consideration for environmental and food safety. Compared to free silicic acid, which is already used in crop protection, the silica nanoparticles caused less stress to the plants and to other soil microorganisms due to the slow release of the silicic acid. The study, published in the top-ranking journal Nature Nanotechnology, shows that silica nanoparticles could serve as an inexpensive, highly efficient, safe, and sustainable alternative for plant disease protection.

Future research could extend the investigations to a broader spectrum of plant pathogens according to the researchers such as other bacteria, insects, or viruses. They emphasize though that before any broad application of nanoparticles as nano-biostimulants and -fertilizers, a thorough analysis is needed to assess the potential long-term fate of silica nanoparticles in the environment.

The study, a collaboration led by AMI BioNanomaterials Ambizione Fellow Dr. Fabienne Schwab and postdoctoral researcher Dr. Mohamed El-Shetehy (Department of Biology, University of Fribourg), was preceded by a first application project. Schwab developed the patented degradable nanoparticles for the targeted delivery of active ingredients and to stimulate plant resistance. With support from Innosuisse, the Swiss Innovation Agency, Schwab and her partners at the University of Applied Sciences and Arts Western Switzerland – Fribourg and the Bern University of Applied Sciences' School of Agricultural, Forest and Food Sciences have been performing field trials and upscaling the production of the nanoparticles.

Reference

El-Shetehy, M.; Moradi, A.; Maceroni, M.; Reinhardt, D.; Petri-Fink, A.; Rothen-Rutishauser, B.; Mauch, F.; Schwab, F. Silica Nanoparticles Enhance Disease Resistance in Arabidopsis Plants. *Nat. Nanotechnol.* **2021**, 16 (3), 344–353.

Dr. Fabienne Schwab joined AMI in 2016 with an Ambizione grant awarded by the Swiss National Science Foundation to investigate plant-nanoparticle interactions. She is currently the director of the Innosuisse project CLEAN.

BioNanomaterials

Team

Prof. Alke Fink, Prof. Barbara Rothen-Rutishauser, Liliane Ackermann, Mauro Almeida, Dr. Sandor Balog, Dr. Anne Bannuscher, Hana Barosova, Nils Berger, Jessica Caldwell, Shui Ling Chu, Dr. Yendry Corrales, Irini Dijkhoff, Dr. Barbara Drasler, Manuela Estermann, Bihter Geers, Dr. Christoph Geers, Laetitia Haeni, Christina Glaubitz, Dr. Gowsinth Gunasingam, Dr. Begum Bedia Karakocak, Daria Korejwo, Aaron Lee, Dr. Roman Lehner, Dr. Carmen Martin, Dr. Ana Milosevic, Aura Moreno, Dr. Roberto Ortuso, Benedetta Petracca, Dr. Fabienne Schwab, Dr. Dedy Septiadi, Giovanni Spiaggia, Lukas Steinmetz, Eva Susnik, Dr. Patricia Taladriz, Dr. Angel Tan, Mathias Weyland, Phattadon Yajan.

Key Publications

1. Septiadi, D.; Lee, A.; Spuch-Calvar, M.; Moore, T. L.; Spiaggia, G.; Abdussalam, W.; Rodriguez-Lorenzo, L.; Taladriz-Blanco, P.; Rothen-Rutishauser, B.; Petri-Fink, A. Particle Surfaces to Study Macrophage Adherence, Migration, and Clearance. *Adv. Funct. Mater.* **2020**, 30 (34), 2002630.

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4. Barosova, H.; Maione, A. G.; Septiadi, D.; Sharma, M.; Haeni, L.; Balog, S.; O'Connell, O.; Jackson, G. R.; Brown, D.; Clippinger, A. J.; Hayden, P.; Petri-Fink, A.; Stone, V.; Rothen-Rutishauser, B. Use of EpiAlveolar Lung Model to Predict Fibrotic Potential of Multiwalled Carbon Nanotubes. *ACS Nano* **2020**, 14 (4), 3941–3956.

5. El-Shetehy, M.; Moradi, A.; Maceroni, M.; Reinhardt, D.; Petri-Fink, A.; Rothen-Rutishauser, B.; Mauch, F.; Schwab, F. Silica Nanoparticles Enhance Disease Resistance in Arabidopsis Plants. *Nat. Nanotechnol.* **2021**, 16 (3), 344–353.

Come together

_ Getting a clearer picture of amyloid aggregation

Researchers from the Adolphe Merkle Institute's BioPhysics group have applied atomic force microscopy to improve imaging of protein aggregates and their precursors responsible for the development of brain disorders such as Alzheimer's Disease.

Amyloids are aggregates of proteins that are linked to a number of human pathologies, among them neurodegenerative disorders such as Parkinson's or Huntington's diseases. The presence of aggregated amyloid β (Aβ), in the form of senile plaques and neurofibrillary tangles of microtubule-binding protein tau in the brain, is considered the histopathological hallmark of another neurodegenerative illness, Alzheimer's dementia (AD). Its two most common forms, Aβ-40 and Aβ-42, are both potential targets to treat AD. Aβ-42 is the form most frequently found in patients' brains, and the emerging scientific consensus is that its earlier, small and soluble aggregates are generally more neurotoxic than insoluble mature fibrils and dense fibril meshes, otherwise known as senile plaques.

To visualize Aβ aggregates and to understand how quickly they form, researchers rely on a variety of imaging and analytical techniques. For the most part though, these techniques do not provide a comprehensive picture, because they cannot visualize the size and shape changes that especially the smallest Aβ aggregates undergo inside physiological solutions. Atomic force microscopy (AFM) can overcome this hurdle. An atomic force microscope operates by scanning a small cantilever over the surface of a sample, creating a topographical map of it on the nanoscale. This procedure provides images with a resolution in the nanometer range, and is suitable for imaging of individual proteins and their aggregates. For the best results, the imaging should be carried out on an uncontaminated and artifact-free interface. This requirement is crucial because of the small dimensions of the Aβ peptides: the presence of any contaminants could be mistaken as amyloid aggregates, unlike with extended biomolecules such as DNA, which can be recognized in the image. To obtain morphological information on amyloid nanostructures with an AF microscope, the Aβ peptides must be adsorbed on a solid surface and maintained in a hydrated state. The surface must also be free from any contaminants, even under ambient conditions. To meet this challenge, the AMI researchers investigated an interface with a graphene surface and pure water. This approach resolved both the soluble forms (monomers and oligomeric aggregates) and insoluble forms (protofibrils with nodular morphology, mature single fibrils, and fibril networks) of Aβ-40 and Aβ-42 with single-particle resolution.

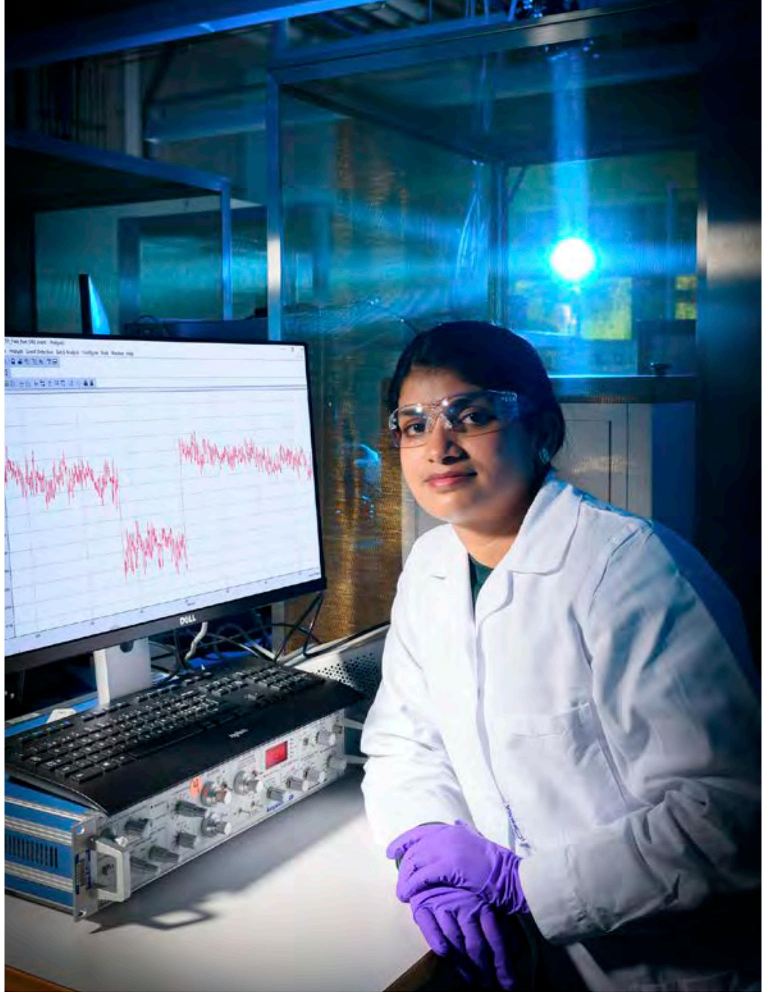
"What was important is that we were able to develop a technique that does not require special labelling or staining, and which allows us to follow the complete amyloid aggregation pathway from start to finish without unwanted artifacts," says AMI alumnus Peter Nirmalraj, who led the research.

While monitoring changes in oligomer diameter up to 150 hours, the researchers noted faster aggregation rates for peptide Aβ-42 compared to peptide Aβ-40. The resulting mature fibrillar networks showed that those made up of Aβ-42 contained longer, more densely packed and aligned fibrils than networks from Aβ-40. This effect has also been shown on surfaces other than graphene, confirming that the alignment was not influenced by the surface used.

"This hierarchical assembly of the fibrils may be a useful physical property for engineering functional bionanomaterials, because the elongated fibrils with high aspect ratio remain stable under ambient conditions", adds Nirmalraj.

Reference

Nirmalraj, P. N.; List, J.; Battacharya, S.; Howe, G.; Xu, L.; Thompson, D.; Mayer, M. Complete Aggregation Pathway of Amyloid β (1–40) and (1–42) Resolved on an Atomically Clean Interface. *Sci. Adv.* **2020**, 6 (15), eaaz6014.



Dr. Vandana Singh Kushwaha joined the AMI BioPhysics group in 2020 as a postdoctoral researcher. She is currently investigating single-protein analysis using solid-state nanopores.

BioPhysics

Team

Prof. Michael Mayer, Dr. Saurabh Awasthi, Dr. Louise Bryan, Jessica Dupasquier, Dr. Anirvan (Gogol) Guha, Stéphane Hess, Dr. Alessandro Ianiro, Trevor Kalkus, Edona Karakaci, Dr. Vandana Kushwaha, Yuanjie Li, Dr. Peng Liu, Dr. Tianji Ma, Dr. Jonas Pollard (Macromolecular Chemistry), Dr. Samuel Raccio (Macromolecular Chemistry), Marian Reincke, Dr. Maria Taskova, Anna Wald, Chanakul Wachara, Shuran Xu, Dr Cuifeng Ying.

Key Publications

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2. Awasthi, S.; Sriboonpeng, P.; Ying, C.; Houghtaling, J.; Shorubalko, I.; Marion, S.; Davis, S. J.; Sola, L.; Chiari, M.; Radenovic, A.; Mayer, M. Polymer Coatings to Minimize Protein Adsorption in Solid-State Nanopores. *Small Methods* **2020**, 4 (11), 2000177.

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Going meta

_ Shining a new light on materials

Researchers from the Soft Matter Physics group at the Adolphe Merkle Institute are designing new materials that display intriguing optical properties, with a fabrication process that promises to be more efficient than previously employed methods.

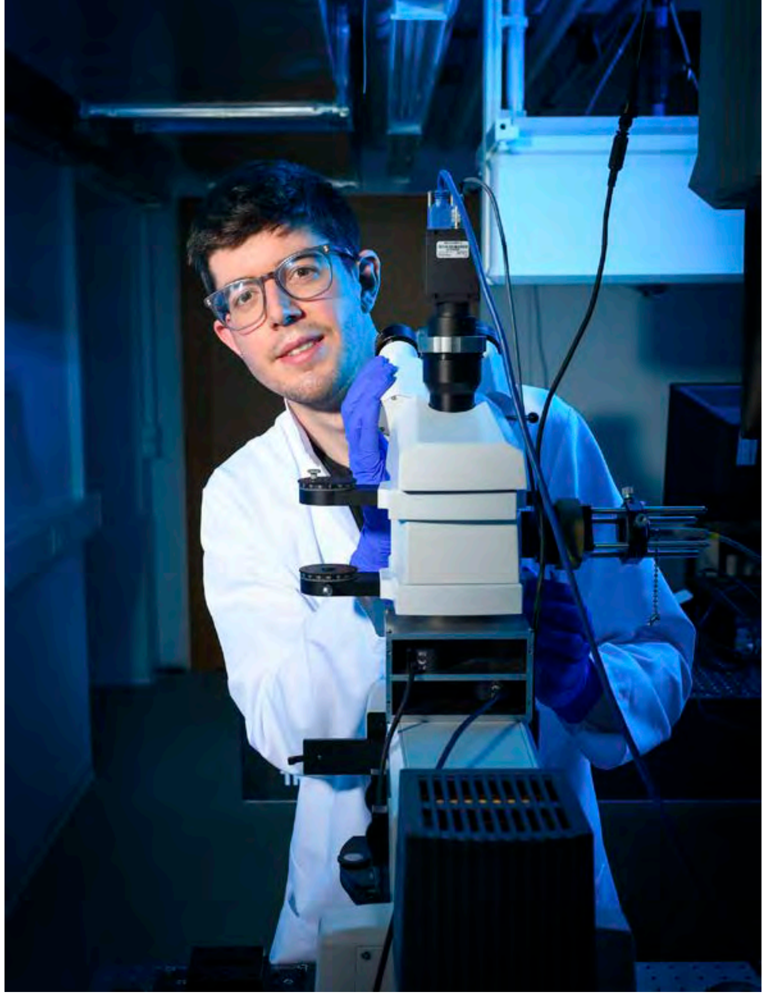
Metamaterials are artificial materials that can be tuned to reflect and redirect light in a highly controlled manner. In a sense, they act like lenses, but they display certain unique characteristics that cannot be found in traditional optical elements. Over the past two decades, metamaterials have led to an increasing number of biosensing and nanophotonic applications, for example to identify proteins, thanks to the careful control of light propagating through subwavelength features.
Researchers from the AMI Soft Matter Physics group have investigated chiral nanostructures that are characterized by the absence of any mirror symmetry. These metamaterials most notably display unique properties such as circular dichroism (CD) and optical activity, and others not found in nature. CD is the difference in absorption of left and right circularly polarized light, and is applied in different types of spectroscopy to the structural study of proteins, or to determine geometric and electronic structures of molecules for example. It has even been predicted that these nanostructures could have negative refractive indices, leading potentially to the development of an invisibility cloak or other new optical devices.

The researchers focused on creating three-dimensional (3D) chiral structures that could display strong CD at visible and near-infrared wavelengths, while being relatively simple to assemble. Nanostructures with those features have been particularly challenging to create, and are limited by the very nature of their structures, or because of the time required to produce a satisfactory result. Most studies have focused on helical structures arranged in 2D arrays, which produce strong CD, but are cumbersome and costly, with limited features. The AMI scientists chose to develop self-assembled structures instead, an approach that offers no limitations to feature size and can be of a chosen 3D morphology. Their metamaterial was based on the replication of a gyroid, an inherently chiral 3D structure, in block copolymer films. One of the polymer elements is removed from the film, and replaced with gold or silver by electrochemical backfilling. The remaining polymer is then removed, leaving only the metallic gyroid structure.

The method used by the AMI researchers is more efficient than previous attempts using self-assembled techniques such as DNA origami, peptide, and cellulose nanocrystal templates, with much stronger CD. It affords materials that display similar results as structures made with more costly techniques. The AMI nanostructures are also easier to tune thanks to their material composition, and respond to a wider range of wavelengths. With the silver gyroid structures investigated proving to have a stronger CD than the gold ones, the results pave the way to a simpler fabrication of 3D self-assembled silver optical materials. Applications could include tunable CD filters and large-scale materials for chiral sensing, while variations of the gyroid structure could further improve CD.

Reference

Kilchoer, C.; Abdollahi, N.; Dolan, J. A.; Abdelrahman, D.; Saba, M.; Wiesner, U.; Steiner, U.; Gunkel, I.; Wilts, B. D. Strong Circular Dichroism in Single Gyroid Optical Metamaterials. *Adv. Opt. Mater.* **2020**, 8 (13), 1902131.



Cédric Kilchoer joined the AMI Soft Matter Physics group in 2017 for his PhD studies, after completing a Master's degree at Lausanne's Federal Institute of Technology (EPFL). He graduated in 2020 and continued working in the group as a senior researcher.

Soft Matter Physics

Team

Prof. Ullrich Steiner, Prof. Jovana Milic, Doha Abdelrahman, Narjes Abdollahi, Martino Airoldi, Viola Bauernfeind, Johannes Bergmann, Dr. Esteban Bermudez, Kenza Djegdhi, Parnian Ferdowsi, Dr. Reza Ghanbari, Antonio Guenzler, Dr. Ilja Gunkel, René Iseli, Dr. Cédric Kilchoer, Mirela Malekovic, Dr. Guillaume Moriceau, Tri Minh Nguyen, Dr. Efrain Ochoa, Andrea Palumbo, Alessandro Parisotto, Cristina Prado, Alexandre Redondo, Dr. Matthias Saba, Cédric Schumacher, Dr. Wenhui Wang, Dr. Bodo Wilts.

Key Publications

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3. Kilchoer, C.; Abdelrahman, D.; Abdollahi, S. N.; LaRocca, A. A.; Steiner, U.; Saba, M.; Gunkel, I.; Wilts, B. D. Hyperbolic Optical Metamaterials from Shear-Aligned Block Copolymer Cylinder Arrays. *Adv. Photon. Res.* **2020**, 1 (2), 2000037.

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In brief

Promotions

Two Adolphe Merkle alumni from the Polymer Chemistry & Materials group were appointed to new positions at universities abroad.

Dr. Yoshimitsu Sagara, who was a postdoctoral fellow in AMI from 2013 to 2015, was appointed as Associate Professor in the Department of Materials Science and Engineering at the Tokyo Institute of Technology, after serving for several years as an Assistant Professor at the University of Hokkaido.

Dr. Céline Calvino, who completed her PhD at AMI in 2018, was appointed Junior Research Group leader at the University of Freiburg's Cluster of Excellence livMatS in Germany. After her graduation, Calvino first joined the University of Chicago as a postdoctoral fellow.

From slime to 3D printing

The Adolphe Merkle Institute BioNanomaterials group was awarded over CHF 24,000 in seed funding by the State Secretariat for Education, Research and Innovation for a collaborative project with Costa Rica's National Laboratory of Nanotechnology on 3D hydrogel printing.

The funded project builds on earlier studies carried out at AMI by alumna Dr. Yendry Corrales, a postdoctoral researcher who investigated the slime of the Costa Rican velvet worm. The slime is a composite material formed by a protein matrix and vesicles containing inorganic salts, with the strength of petroleum-derived polymers such as nylon, but also with the added advantages of being protein-based and biodegradable. It has been considered a potential model to formulate new bio-inspired materials to replace petroleum-derived plastics such as polyester or acrylics.

The aim is to develop a potential first application inspired by the worm slime's unique hydrogel gelling and fast drying mechanism – an accessible and simple 3D printing system. In recent years, the use of hydrogels combined with 3D-printing has revolutionized the field of biomaterials, allowing for the customized fabrication of functional hydrogel scaffolds for tissue engineering, delivery systems, implants, diagnostic devices, and soft electronics. The project's ambitious goal is to provide, for the first time, developing rural developing communities with access to customized hydrogels for their medical care requirements.

The hydrogel formulation and instrument development is being carried out in Costa Rica, while 3D-printing, nanocarrier synthesis and characterization, and development of stimuli-responsive materials will take place in Switzerland at the AMI.

NCCR directorship

Professor Ullrich Steiner, AMI's Chair of Soft Matter Physics, took over in 2020 the directorship of the National Center of Competence in Research (NCCR) Bio-Inspired Materials based at the University of Fribourg. Professor Steiner joined AMI in 2014 from the University of Cambridge, where he was a member

of the Cavendish Laboratory. He took the baton from Professor Christoph Weder, the Institute's Director and Chair of Polymer Chemistry & Materials, who headed up the Center since its creation in 2014. Steiner's Deputy Director is Professor Esther Amstad of Lausanne's Federal Institute of Technology (EPFL). The duo's primary efforts are currently focused on stewarding the center into the next, and final, four-year funding phase, which will begin in 2022.

PhD prizes

Two Adolphe Merkle Institute alumni have been recognized for the quality of their PhD theses.

Hana Barosova was awarded the 2020 Faculty Prize for best doctoral thesis in life sciences at the University of Fribourg. Barosova, who was a member of the AMI BioNanomaterials group, was recognized by the Faculty of Science and Medicine for the work leading to her PhD on "3D human co-cultures for predicting nanomaterial possible adverse effects on human health with a focus on multi-walled carbon nanotubes". She developed an in vitro testing strategy for aerosolized nanomaterials mimicking occupational exposure conditions. This included the implementation of reliable and responsive human alveolar cell culture models, as well as an exposure scenario for repeated long-term exposures of nanomaterials exposed to lungs cells the air-liquid interface.

Omar Rifaie Graham, previously of the Macromolecular Chemistry group, was the recipient of the University's 2019 prize for best experimental thesis. The award was in recognition of his PhD project "Cell inspired force and light responsive polymersome nanoreactors and polymerisation based diagnostics". His work was also influential for the AMI malaria diagnostics project Hemolytics.

Habilitation

Dr. Bodo Wilts, a postdoctoral researcher from the Soft Matter Physics group, was the first Adolphe Merkle Institute group leader to complete the requirements for a Habilitation at the University of Fribourg and received his venia legendi – the right to teach independently – from the Faculty of Science and Medicine in March 2020. Wilts has since been appointed to a professorship at the University of Salzburg, where he will take up his position in October 2021. Wilts' work at AMI has focused notably on photonic structures found in nature and functional optical materials.

Gender equality

AMI's BioNanomaterials co-chair Professor Barbara Rothen-Rutishauser was interviewed for Elsevier's special report "The researcher journey through a gender lens: A global examination of research participation, career progression and perceptions", published in March 2020.

The interview covered notably Rothen-Rutishauser's realization that the academic playing field was anything but level for men and women, and that concrete actions were required to correct the gender imbalance in science at least. She saw notably that many female researchers did not have sufficient backing from others that would give them the confidence to succeed, They would move away from research, taking years of experience with them.

In her role as Faculty Delegate for the Advancement of Young Researchers and Women of the National Center of Competence in Research Bio-Inspired Materials, Rothen-Rutishauser has been instrumental in organizing roundtables for female researchers to share their experiences and get feedback and advice. She is also the recipient, along with her colleagues Professor Alke Fink and Dr. Sofía Martín Caba, of the Agents of Change Award. The award recognizes initiatives and programs that focus on driving gender equality in the materials science research community. The program initiated by the three recipients is centered around improving the professional confidence of women scientists.

New Fellows

Two AMI researchers were awarded prestigious Marie Skłodowska-Curie fellowships in 2020.

Dr. Alessandro Ianiro, a postdoctoral researcher in the BioPhysics group, was selected for his project, funded by the European Commission, focusing on the development of a novel class of nanocomposite materials that mimic natural muscles by combining stimuli-responsive hydrogels and colloidal liquid crystals. Hydrogels are soft, shape-compliant materials that are widely used for actuators, but they generally exhibit poor mechanical resistance and, unlike natural muscles, do not expand in a specific direction. Ianiro will try to overcome these limitations by combining hydrogels with colloidal particles, and orienting these hybrid materials along a preferential direction. he expects that this approach will lead to a novel class of soft actuators that will bring significant advancement to fields such as robotics and medicine.

Postdoctoral researcher Dr. Philip Scholten was also awarded the same fellowship to develop degradable commodity plastics to help reduce incineration and landfill use to eliminate these materials, and improve levels of recycling. His project focused on the development of a new family of environmentally degradable polymers. The need for more sustainable and environmentally-friendly products and materials is driven by an increasing environmental and health awareness, opening new markets with significant economic potential. Building on the expertise of the AMI Polymer Chemistry and Materials group in the area of metallosupramolecular polymers, Scholten investigated new polymers that disassemble into their building blocks after sustained exposure to water.

Swiss Youth in Science

The Adolphe Merkle Institute hosted the final event of the Swiss Youth in Science chemistry and materials science study week in February 2020.

The event was an opportunity for the college students who participated in the program to present their work to their peers and mentors. A number of the participants had spent the week working on their projects at AMI, mentored by PhD students and postdoctoral researchers, and were able to access top-of-the-line scientific equipment.

Sparking ideas

Three AMI researchers were awarded a Spark grant by the Swiss National Science Foundation.

The aim of the Spark program is to fund the rapid testing or development of new scientific approaches, methods, theories, standards, and ideas for applications for example. It is intended to support projects that show unconventional thinking and introduce a unique approach. The focus is on promising ideas of high originality, and applicants are encouraged to take risks.

Dr. Saurabh Awasthi, a postdoctoral researcher from the BioPhysics group, is focusing on the detection of Tau protein oligomers, whose presence can promote the development of Alzheimer's disease. Current assays for these proteins in cerebrospinal fluid do not provide information on the size or shape-distribution of Tau oligomers, which are both indicators of their potential toxicity. Awasthi will develop a nanopore detection system to characterize and quantify Tau oligomers in biological fluids on a single particle level, by binding them with Tau specific antibodies that recognize them.

Dr. Stephen Schrettl, a group leader in the Polymer Chemistry & Materials group, is investigating innovative composites that respond to external stimuli. Materials that respond and adapt to changes in their environment in a useful way have great potential for a variety of industrial applications. Schrettl plans to develop an attractive, conceptually simple, and versatile approach to prepare such materials. To achieve this, the researchers will incorporate microcapsules into a polymer, and the resulting composite materials can respond to stimuli by releasing a cargo from the capsules, which in turn can be used to change the polymer's properties in different ways.

Dr. José Augusto Berrocal, another group leader in the Polymer Chemistry & Materials group, aims to develop bio-inspired systems that are capable of generating electricity in a sustainable way, namely by using ubiquitous stimuli from our daily lives and without the use of fossil fuels or non-renewable sources. His inspiration is the mechanism used by plants to convert sunlight into chemical energy via complex molecular systems. In nature, this transduction relies on the generation of electrochemical gradients across biological membranes. Berrocal plans to synthesize molecules and polymers that can shuttle protons – positively charged elementary particles found in the nuclei of all atoms – upon stimulation with light or mechanical force, thereby creating chemical gradients from which electrical power can be harnessed.


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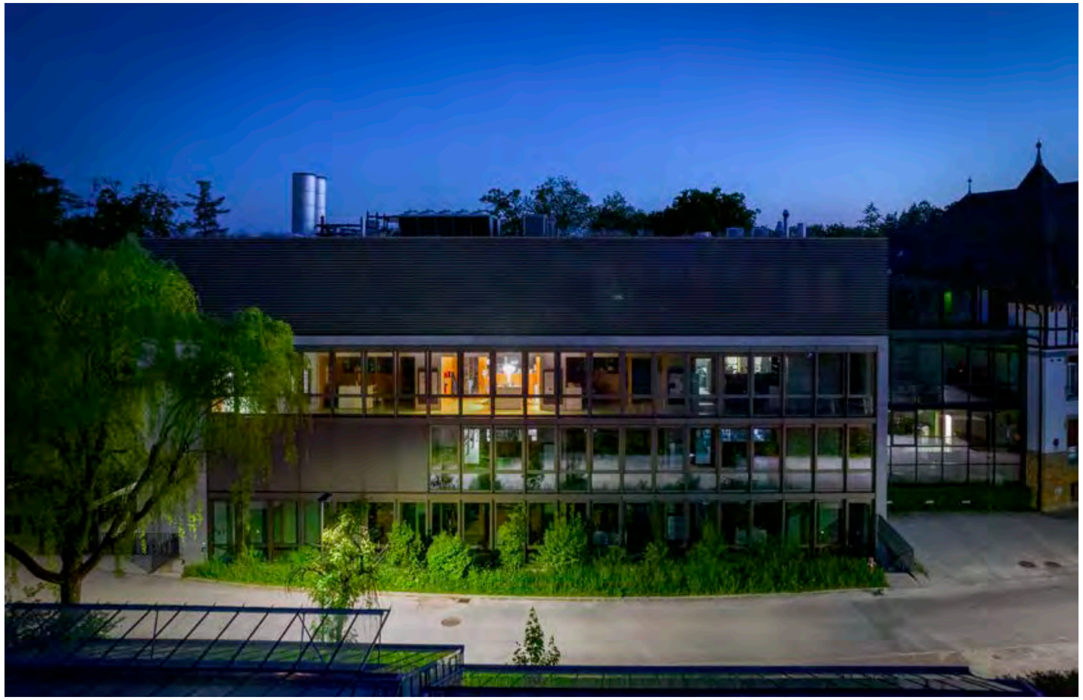
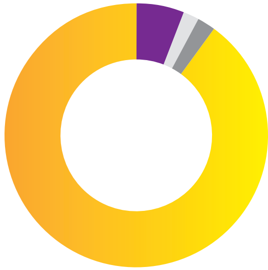
Finance & Organization

Finance
_ Cost structure at AMI



The Adolphe Merkle Institute's overall expenditures in 2020 were CHF 9.95 million. 90% of this sum was spent on research, while an additional 2% was invested in research equipment. Around 2% of the budget supported valorization activities such as technology transfer, and communication & marketing, with another 6% used for administration costs.

Overall expenses 2020
CHF 9.95 million



- Research / 90%
- Administration / 6%
- Valorization / 2%
- Research equipment / 2%

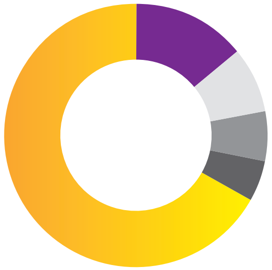
Funding sources of overall expenses 2020

- Adolphe Merkle Foundation / 32%
- Grants / 54%
- University of Fribourg / 10%
- Industry / 4%

Funding sources of research projects 2020
CHF 8.9 million

- Adolphe Merkle Foundation / 30%
- Public Funding / 51%
- University of Fribourg / 11%
- Industry / 4%
- Other / 4%

Third-party funding 2020
CHF 5.8 million



- SNSF / 67%
- EU / 14%
- Industry / 8%
- Innosuisse / 6%
- Other sources / 5%

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 along with the Associate Director. 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
State Minister in charge of Education, Culture and Sport of canton Fribourg

Chantal Robin
Director, Fribourg Chamber of Commerce and Industry

Prof. Rolf Mülhaupt
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. Astrid Epiney (President)
Rector of the University of Fribourg, Professor at the Faculty of Law, University of Fribourg

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

Prof. Ulrich Ultes-Nitsche
Professor in the Department of Informatics, University of Fribourg

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

Scientific Advisory Board

Members

Dr. Alan D. English (President)
Senior Research Fellow, DuPont Central Research and Development, USA

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Institute of Supramolecular Science and Engineering (ISIS), University of Strasbourg, France

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Head Laboratory of Physics of Living Matter, EPFL, Switzerland

Prof. Alex Dommann
Head of Department "Materials meet Life", Empa, St. Gallen, Switzerland

Prof. Paula Hammond
David H. Koch Professor in Engineering, and Executive Officer, MIT, USA

Prof. em. Heinrich Hofmann
Former head of the Powder Technology Laboratory, EPFL, Switzerland

Dr. Alexander Moscho
Executive Vice President Chief Strategy Office, UCB

Prof. Dieter Richter
Head Institute of Solid State Research, Forschungszentrum Jülich, Germany

Prof. Marcus Textor
Former Head of Biointerface Group at Department of Materials, ETH Zürich, Switzerland

Prof. Ben Zhong Tang
Chair Professor of Chemistry, Hong Kong University of Science and Technology, China

Executive Board

Prof. Christoph Weder
Director and Chair of Polymer Chemistry & Materials

Prof. Alke Fink
Co-Chair of BioNanomaterials

Prof. Michael Mayer
Chair of Biophysics

Prof. Barbara Rothen-Rutishauser
Co-Chair of BioNanomaterials

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

Administration

Scott Capper
Responsible for Communications & Marketing

Melissa Forney-Hostettler
Secretary

Carine Jungo
Secretary

Catherine Jungo
Responsible for Human Resources

Thierry Mettraux
Responsible for Finance & Controlling

Dr. Valeria Mozzetti
Head of Knowledge and Technology Transfer, Grant Writing

Tomas Perez
Responsible for IT Support

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_ PhDs & Alumni

PhDs

Our new doctors

Bernadetta Gajewska
(Macromolecular Chemistry)
"Chlorophylls as catalysts of Controlled Radical Polymerization"

Gogol (Anirvan) Guha
(BioPhysics)
"Bio-Inspired Energy-Converting Materials"

Diana Hohl
(Polymer Chemistry & Materials)
"Structure-property relationships in reversible supramolecular polymer adhesives"

Cédric Kilchoer
(Soft Matter Physics)
"Nanostructured Optical Materials: From Biological Photonic Structures to Block Copolymer-based Plasmonic Materials"

Mirela Malekovic
(Soft Matter Physics)
"Order and disorder in nature inspired 1-D photonic structures"

Samuel Raccio
(Macromolecular Chemistry)
"Polymerization-based amplification as a tool for malaria diagnostics"

Felipe Saenz
(Polymer Chemistry & Materials)
"Nanostructured Polymers Enabling Stable Low-Intensity Light Upconversion"

Lukas Steinmetz
(BioNanomaterials)
"Lock-in thermography for the analysis of plasmonic nanomaterials"

Alumni

People who left AMI in 2020

Hana Barosova
(BioNanomaterials)

Yendry Corrales
(BioNanomaterials)

Barbara Drasler
(BioNanomaterials)

Mohamed El-Shehety
(BioNanomaterials)

Reza Ghanbari
(Soft Matter Physics)

Diana Hohl
(Polymer Chemistry & Materials)

Patricia Johnson
(Polymer Chemistry & Materials)

Feyza Karasu Kiliç
(Polymer Chemistry & Materials)

Samuel Laubscher
(Administration)

Mirela Malekovic
(Soft Matter Physics)

Carmen Martin
(BioNanomaterials)

Ana Milosevic
(BioNanomaterials)

Guillaume Moriceau
(Soft Matter Physics)

Lukas Steinmetz
(BioNanomaterials)

Angel Tan
(BioNanomaterials)

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