UNDERGRADUATE SUMMER RESEARCH INTERNSHIPS
National Center of Competence in Research for Bio-Inspired Materials

Research Projects Summer 2021

The National Center of Competence in Research (NCCR) Bio-Inspired Materials offers undergraduate students (from Switzerland and abroad) the opportunity to spend the summer break (8-12 weeks) participating in cutting-edge research within one of the Center's research groups. The undergraduate students have the opportunity to work on a research project and to interact with leading experts in their fields of interest and with fellow students from around the world. The students get a glimpse of advanced research work, gain desirable hands-on work experience, develop their transferable skills and have the unique opportunity to explore career options and network with professionals. Beyond conducting research in the hosting lab, undergraduates participate in scientific lectures, social and networking events. At the end of the summer, the students present the results of their research projects in a poster session followed by a summer party. The students have the opportunity to learn about Switzerland from an insider perspective, and to take the first steps toward learning or practicing French and/or German language skills.

Requirements

To apply to the program, you need to fulfill the conditions to be found on our website.

Terms of the research stay

Duration: 8-12 weeks; Only Period II (June 15 – September 15)

How to apply

Applicants must submit their applications online at www.bioinspired-materials.ch/

Applications are open from December 1, 2020 until January 20, 2021.

Project ID	Project title	Group	Field	Possible period
P21-01_Acuna	Building up a displacement assay by using DNA nanotechnology	Acuna	Biology, Biochemistry, Chemistry, Physics, Material Science & Engineering	II
P21-02_Acuna	Plasmon - quantum emitters interactions using DNA self-assembly	Acuna	Chemistry, Physics, Material Science & Engineering	II
P21-03_Amstad	Bioinspired mineral hydrogel nanocomposites	Amstad	Material Science & Engineering	II
P21-04_Fink	Engineering nanoparticle rigidity for controlling cellular interactions	Fink	Chemistry, Material Science & Engineering	II
P21-05_Fromm	Ferrocene-DNA conjugates as mechanophores in polymers	Fromm	Chemistry	II
P21-06_Kilbinger	Amphiphilic aromatic oligoamides inspired by human cathelicidin peptide LL-37	Kilbinger	Chemistry	II
P21-07_Mayer	Bio-inspired energy conversion: Novel approaches to reserve electrodialysis	Mayer	Chemistry, Biology, Biochemistry, Physics, Material Science & Engineering	II
P21-08_Mayer	Single-protein characterization by plasmonic optical trapping	Mayer	Biology, Physics, Biochemistry, Material Science & Engineering	II
P21-09_Mayer	Solid state nanopores for single molecule characterization	Mayer	Physics, Biochemistry, Medicine, Material Science & Engineering	II
P21-10_Rothen	Stimulation of nanoparticle endocytosis in A549 cells by epidermal growth factor	Rothen	Biochemistry, Medicine	II
P21-11_Rothen	Stimulation of cellular endocytosis for enhancing nanoparticle uptake	Rothen	Biology	II
P21-12_Rüegg	DNA origami biosensor for the detection of cancer biomarkers	Rüegg	Biology, Biochemistry, Medicine, Material Science & Engineering	II
P21-13_Salentinig	Antimicrobial peptide inspired materials for killing bacteria	Salentinig	Chemistry, Material Science & Engineering	II
P21-14_Steiner	Nanostructured optical metamaterials made by block copolymer self-assembly	Steiner	Physics, Materials Science & Engineering	II
P21-15_Steiner	Mesoporous anode material Li4Ti5O12 (LTO) for lithium ion batteries	Steiner	Chemistry, Physics, Materials Science & Engineering	II
P21-16_Steiner	Characterizing unknown insect structures to model and develop functional materials	Steiner	Biology, Physics, Materials Science & Engineering	II
P21-17_Steiner	Bioinspired materials for hybrid photovoltaics	Steiner	Chemistry, Physics, Materials Science & Engineering	II
P21-18_Studart	Magnetic soft microfluidic pumps within the chip	Studart	Chemistry, Physics, Materials Science & Engineering	II
P21-19_Vanni	Improving the design of self-assembling artificial water channels	Vanni	Chemistry, Physics, Materials Science & Engineering	II
P21-20_Weder	Cephalopod-inspired mechano-reporting polymeric materials	Weder	Chemistry, Materials Science & Engineering	II

P21-21_Weder	Bio-inspired mechanically morphing and stimuli responsive composites	Weder	Chemistry, Materials Science & Engineering	II
P21-22_Weder	Light-responsive polymersomes for light-triggered release	Weder	Chemistry, Materials Science & Engineering	II
P21-23_Weder	Mechanochromic loopy structures based on weak dye interactions	Weder	Chemistry, Physics, Materials Science & Engineering	II

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Project ID	**URI P21-01_Acuna**
Project title	**Building up a displacement assay by using DNA nanotechnology**
Research group	Prof. Guillermo Acuna https://www3.unifr.ch/phys/en/
Host Institution	Department of Physics, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Aim of the project is to develop a displacement assay to detect cancer RNA. Based on silver or gold nanoparticle dimer structures (optical antennas), the change of the fluorescent signal by binding and unbinding of a target RNA strand should be studied by fluorescent microscopy. To build up these structures the method of DNA origami is used, which is well established in our lab.

In general, the following intermediate goals can be reached:

- Assembly of DNA origami structures
- Functionalization of AgNP with DNA
- Assembly and characterization of optical antenna structures, e.g. Ag/AuNP@DNA origami structures
- Single fluorescence measurements by optical microscopy
- Study of the fluorescence signal by binding and unbinding of the RNA target strand to the antenna structure.

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Project ID	**URI P21-02_Acuna**
Project title	**Plasmon - quantum emitters interactions using DNA self-assembly**
Research group	Prof. Guillermo Acuna https://www3.unifr.ch/phys/en/
Host Institution	Department of Physics, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Interactions between plasmons (e.g. of ~60nm gold nanoparticles) and quantum emitters positioned nearby (e.g. fluorophores) display rich physical phenomena ranging from modification of fluorescence emission to plasmon-quantum emitter energy hybridization. Using DNA self-assembly, one can fabricate structures containing a pre-determined number of components (e.g. 2 nanoparticles and one single fluorophore) as well as control their inter-spacing and geometrical arrangement. This in turn tunes the degree of interaction.

During this project, the student will:

- Fabricate the structures using DNA self-assembly technique.

- Perform optical measurements including confocal and widefield fluorescence microscopies, and scattering and fluorescence spectroscopies of single structures.

- Characterize the structures using transmission and scattering electron microscopes.

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Project ID	**URI P21-03_Amstad**
Project title	**Bioinspired mineral hydrogel nanocomposites**
Research group	Prof. Esther Amstad https://smal.epfl.ch/
Host Institution	Soft Materials Laboratory, EPF Lausanne
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Hydrogels are polymeric networks encompassing large amounts of water. Thanks to their high biocompatibility, hydrogels were among the first biomaterials expressly designed for their use in biomedicine. However, state-of-the-art applications of hydrogels are severely limited due to their poor mechanical properties. To increase the versatility of hydrogels for load-bearing applications, new strategies that combine covalent and physical interactions have been developed. However, these hydrogels are either stiff but brittle or strong but weak. To fabricate hydrogels that are stiff and strong at the same time, new fabrication approaches are required. Inspired by nature, we are developing granular hydrogels that can optionally be mineralized to increase their stiffness.

This project aims at developing a bioinspired hydrogel nanocomposite composed of a hydrogel scaffold that is infiltrated with inorganic nanoparticles, which displays mechanical properties that are more similar to those of cartilage than the currently known composites. Within this project, you will fabricate single network hydrogels and investigate the effect of ion infiltration on their mechanical properties using rheology and tensile testing.

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Project ID	**URI P21-04_Fink**
Project title	**Engineering nanoparticle rigidity for controlling cellular interactions**
Research group	Prof. Alke Fink https://www.ami.swiss/bionanomaterials/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Nanotheranostic agents which are able to provide localized tissue diagnosis and in situ therapeutic delivery remain unrealized despite their immense medical value. Underlying this is the fact that it is still difficult to predict the interaction of nanosized objects with biological systems. Unlike synthetic nanoparticles, viruses possess a wide array of strategies including rigidity control for effective infection. There is a growing body of evidence suggesting that nanoparticle rigidity may be an important design parameter for controlling cellular interactions.

In order to understand the contribution and role of mechanical properties in determining nanobiointeractions, this project will involve synthesis of different nanoparticles with different mechanical properties based on gold-poly(N-isopropylacrylamide) nanocomposites, their characterization and cell culture for probing internalization preferences.

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Project ID	**URI P21-05_Fromm**
Project title	**Ferrocene-DNA conjugates as mechanophores in polymers**
Research group	Prof. Katharina Fromm http://www3.unifr.ch/chem/en/research/groups/fromm/
Host Institution	Department of Chemistry, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

We have shown that ferrocene can act as a mechanophore in polymers such as polyurethane. The next step is to add another mechanophore in order to produce a two-step mechanophore system, one based on DNA-hydrogen bonding (1), and the second on ferrocene (2). While we currently synthesize and investigate the sequence 2-1-polymer, it would also be interesting to make and test the sequence 1-2-polymer in terms of attenuation of mechanical stress (functioning like a safety net). The work includes chemical synthesis (organic, polymer) as well as mechanical testing of materials.

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Research Projects Summer 2021

Project ID	**URI P21-06_Kilbinger**
Project title	**Amphiphilic aromatic oligoamides inspired by human cathelicidin peptide LL-37**
Research group	Prof. Andreas Kilbinger http://homeweb.unifr.ch/kilbinge/pub/kilbinger.html
Host Institution	Department of Chemistry, University of Fribourg
Duration	8 to 12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

In this project, we will synthesize a mono and a di-substituted aromatic amino acid with either only a hydrophilic or both, a hydrophilic and a hydrophobic side chain. These two amino acids will then be coupled to a dimer. This dimer can then be polymerized in a living polycondensation or sequentially oligomerized on a peptide synthesizer. Subsequently, antimicrobial activity of the polymer/oligomer will be investigated in collaboration with the group of Prof. Salentinig (UniFR, see corresponding internship project there).

LL-37 is a 37 residue, alpha-helical, amphipathic, cathelicidin derived antimicrobial peptide. Important for the antimicrobial activity of LL-37 is its spacial distribution of hydrophilic and hydrophobic residues on either side of the alpha-helix. It is believed that the binding of LL-37 to the bacterial cell membrane results in cell rupture/lysis. This physical mode of action is believed not to induce bacterial resistance.

Here, we are trying to mimic the function of this naturally occurring peptide using amphiphilic shape-persistent aromatic amide oligomers. Suitable candidates for this project must have a strong interest in synthetic organic/polymer chemistry.

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Project ID	**URI P21-07_Mayer**
Project title	**Bio-inspired energy conversion: Novel approaches to reserve electrodialysis**
Research group	Prof. Michael Mayer https://www.ami.swiss/biophysics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8 to 12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

The electric eel (Electrophorus electricus) can biologically generate strong electric pulses to sense and incapacitate its prey. The eel contains electrically active cells that each generate 150 mV by manipulating ion gradients across their cell membrane; by stacking thousands of these cells in series, the eel can produce up to 800 V from head to tail.

Utilizing a mechanism similar to that of the eel, reverse electrodialysis (RED), we are able to generate electricity from the ion concentration gradient created when fresh water and sea water mix. However, the electric eel still outperforms RED technology. By creating bio-inspired membranes that more closely mimic those of the electric eel, we hope to increase the power capability of RED. Additionally, we aim to find and create trash-to-treasure scenarios for RED technology. Rather than using fresh water, ion gradients for energy generation can be created from waste products. With this work, we are moving towards energy generation technology with minimal or beneficial environmental impact.

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Research Projects Summer 2021

Project ID	**URI P21-08_Mayer**
Project title	**Single-protein characterization by plasmonic optical trapping**
Research group	Prof. Michael Mayer https://www.ami.swiss/biophysics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	10 to 12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

Plasmonic optical trapping consists of gold nanoholes that can confine the optical field into subwavelength size, inducing an optical trapping force to hold single proteins in the hotspot. The plasmonic resonance shift, introduced by the differences in dielectric constant of proteins from that of water, results changes in the transmission signal through the gold nanohole. When a protein presents in the nanohole, this transmission signal correlates to the Brownian motion and conformation of the trapped protein.

By combining a fluidic system with plasmonic optical trapping, this project aims to observe individual proteins response to different buffer conditions in real-time. The experiments may include optical microscopy, fluidic system and protein preparation.

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Research Projects Summer 2021

Project ID	**URI P21-09_Mayer**
Project title	**Solid state nanopores for single molecule characterization**
Research group	Prof. Michael Mayer https://www.ami.swiss/biophysics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

In this project we make use of the principle of resistive pulse sensing with nanopores for protein characterization. We are working towards real time single molecule analysis in complex biological samples. Particular focus lies on the detection of disease markers such as amyloid-aggregates involved in the progression of Alzheimer's.

To achieve this, strategies to prolong translocation of analytes through the pores, push the detection limit, increase signal to noise ratio of the recordings and achieve a gain in analyte specificity are being developed and refined.

One of our main efforts in this context is to progress nanopore fabrication approaches to form stable pores with precisely defined geometries. To this end we are utilizing and exploring cutting edge techniques such as dielectric breakdown (regular, laser assisted, and AFM coupled) and focused ion beam drilling.

The intern will be involved in the fabrication process of the nanopores as well as the follow up experiments and data analysis.

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Research Projects Summer 2021

Project ID	**URI P21-10_Rothen**
Project title	**Stimulation of nanoparticle endocytosis in A549 cells by epidermal growth factor**
Research group	Prof. Rothen-Rutishauser https://www.ami.swiss/bionanomaterials/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8 to 10 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Endocytosis of cargo receptors can be regulated by ligand binding, e.g. epidermal growth factor (EGF) receptor (EGFR). We will investigate the binding of various nanoparticles with different surfaces (gold, silver, and silica nanoparticles) to an A549 cell line in which the genomic EGFR gene has been endogenously tagged with a Green Fluorescent Protein gene (GFP). This will allow to follow the redistribution of the EGFR from the cell membrane to the endosomal-lysosomal system upon exposure to nanoparticles by fluorescence microscopy. We also will perform experiments by adding epidermal growth factor (EGFR) to compare nanoparticle uptake in stimulated versus control cells.

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Research Projects Summer 2021

Project ID	**URI P21-11_Rothen**
Project title	**Stimulation of cellular endocytosis for enhancing nanoparticle uptake**
Research group	Prof. Rothen-Rutishauser https://www.ami.swiss/bionanomaterials/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8 to 12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Nanoparticle (NPs)-based drug delivery systems have great potential in biomedical applications. However, the treatment can be challenging since a very low amount of NPs reaches the target cells and might not be sufficient to treat the disease. Therefore, it is crucial to discover approaches in order to stimulate NPs uptake and accumulation in target cells. Various stimuli have been described to increase NPs uptake in cells such as functionalization with targeting ligands on the surface or by co-exposure with other NPs. The project focuses on synthetic and bio-inspired substances, which can modulate cellular uptake of NPs. This approach is interesting for nanomedicine where a high accumulation of drug in the target cells is desirable and clearance by immune cells is to be avoided. Different cell types will be exposed to NPs and/or various substances to examine changes in uptake. Cell interactions and uptake of the fluorescent NPs will be assessed by confocal laser scanning microscopy and flow cytometry. Possible impacts on cell viability will be tested by cytotoxicity assay. These results will provide a deeper understanding of NPs behaviour in combination with other NPs or substances to trigger cellular uptake.

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Project ID	**URI P21-12_Rüegg**
Project title	**DNA origami biosensor for the detection of cancer biomarkers**
Research group	Prof. Curzio Rüegg http://www.unifr.ch/med/de/research/cr
Host Institution	Department of Medicine, University of Fribourg
Duration	8 – 12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

In this project, we designed an optical DNA origami biosensor to detect cancer-specific miRNAs. This biosensor consists of three rectangular layers of DNA helices. The upper layer is connected to the middle layer with a hinge from the center allowing the opening of the layer at both sides. Layers are connected with four locks on both sides to keep the device in a closed state. Locks bind to miRNA through toehold mediated strand displacement. To sense the binding of miRNAs, arrays of fluorophores were precisely positioned on the top and middle layers. For fluorescence-based detection, we are exploring two mechanisms: FRET and fluorescence quenchers. Upon addition of miRNA, the locks open, and two layers of DNA helices move apart. The transformation from the closed to open state increases the distance between donor and acceptor fluorophores resulting in a change in fluorescence signal. As a proof of concept, we are testing two breast cancer-related miRNAs expressed in HER2+ and triple-negative breast cancer subtypes. The project on which student will work includes isolation and quantification of miRNA from cells and other biofluids, followed by detection with our biosensor.

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Project ID	**URI P21-13_Salentinig**
Project title	**Antimicrobial peptide inspired materials for killing bacteria**
Research group	Prof. Stefan Salentinig http://www3.unifr.ch/chem/en/research/groups/salentinig/
Host Institution	Department of Chemistry, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

The goal of this project is the design and characterization of antimicrobial polymer structures that mimic the action of natural antimicrobial peptides in killing bacteria by destroying their membrane. We recently discovered that this rather unspecific mode of action can be used to kill even superbugs that are resistant to conventional antibiotics. The student will characterize the self-assembly of synthetic polymer amphiphiles in water and their interaction with bacteria membrane models using i.e. light scattering, small angle X-ray scattering and cryo-TEM. Biological assays on bacteria strains (initially E. Coli) will provide the nanostructure - activity relationship in these materials. The synthesis of the polymer structures will be performed in collaboration with the group of Prof. Kilbinger (see corresponding internship project). The close feedback loop between synthesis / supramolecular structure and activity will guide the design of highly active antimicrobial materials as alternative to conventional antibiotics. The student should have a strong background in physical chemistry related to polymers / materials.

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Project ID	**URI P21-14_Steiner**
Project title	**Nanostructured optical metamaterials made by block copolymer self-assembly**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Optical metamaterials are artificially engineered sub-wavelength materials that open a new field of optics by showing various electromagnetic properties that are not otherwise encountered in nature. Manufacturing such materials requires periodically repeating nanostructures at length-scales that are smaller than the wavelengths they are manipulating. For visible light, this requires the fabrication of 3D nanostructured materials with a periodicity below 100 nm.

Our group routinely fabricates 3D metallic, chiral sub-wavelength nanostructures by using block copolymer self-assembled templates. The summer student will assist in this effort by being involved in: (1) the fabrication of block copolymer templates, (2) replicating the block copolymer film into metallic structures, (3) their optical and topographical characterization using atomic force microscope (AFM), scanning electron microscope (SEM), and optical microscopy and (4) optical simulations of the chiral nanostructures using finite difference time domain method to understand the physical origin of the observed effects. Based on the background of the student, a special focus will be jointly chosen among the mentioned topics.

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Project ID	**URI P21-15_Steiner**
Project title	**Mesoporous anode material Li4Ti5O12 (LTO) for lithium-ion batteries**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

Rechargeable batteries consist of an anode, a cathode and electrolyte materials, all of which have to be optimized in highly performing batteries. LTO is a new mesoporous anode material with great potential, however, its performance is not yet as high as that of graphite, which is the standard Li-ion battery anode. The goal of this project is to improve the performance of LTO for its use in Li-ion batteries.

In this project, you will first learn how to synthesize LTO using sol-gel synthesis. Various advanced analytical techniques (e.g. Scanning electron microscope, X-rays diffraction, Thermogravimetric analysis and Nitrogen physisorption analysis) will then be applied to characterize this material. Once the material is ready, you will be able to build it into a battery to evaluate its performance.

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Research Projects Summer 2021

Project ID	**URI P21-16_Steiner**
Project title	**Characterizing unknown insect structures to model and develop functional materials**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8-12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

Natural selection, taking its course over billions of years can be thought of as a long-running algorithm, that develops unique survival solutions. This has allowed animals to develop a large variety of survival mechanisms with various functional traits. Colour is probably the prime trade. In nature, brilliant colours can be caused by interference of light with nanostructures. Understanding the structure of these coloured insects has the potential to advance modern technology.

Structural coloration appears from the interaction of light with the ordered, quasi-ordered or disordered nanostructures on the insects. In this project, the student will characterize a variety of yet beetles and birds with hitherto undescribed nanostructures by using electron microscopy and optical microscopy. Coupling the structural and optical data will then, based on the student's interest, either allow to model structural colour or place the coloration in a larger ecological and biological context.

Technique: SEM, optical microscopy, optical modelling

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Project ID	**URI P21-17_Steiner**
Project title	**Bioinspired materials for hybrid photovoltaics**
Research group	Prof. Ullrich Steiner https://www.ami.swiss/physics/en/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

Hybrid perovskites have emerged as one of the leading materials for photovoltaics with extraordinary performances in solar-to-electric energy conversion. However, they feature instabilities that severely hinder their practical applications. Some of the underlying reasons for this are associated with detrimental ion migrations under operational conditions of voltage bias and light. While some of the ion migrations are reversible in the dark, others lead to irreversible degradation of the material as well as the resulting solar cells.

This project aims to address this instability by developing hybrid perovskite solar cells that adapt to the operating conditions through the use of bioinspired materials.

This will be achieved by relying on an interdisciplinary approach involving material synthesis and characterization, as well as solar cell device fabrication and analysis towards more resilient photovoltaics.

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Project ID	**URI P21-18_Studart**
Project title	**Magnetic soft microfluidic pumps within the chip**
Research group	Prof. André Studart https://complex.mat.ethz.ch/people/person-detail.html?persid=97284
Host Institution	Department of Materials, ETH Zürich
Duration	9-12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Biologically inspired surfaces typically follow the properties of one particular species or combine those of few species to create a multi-functional surface. Among the types of bio-inspired surfaces with more functions, those that can switch between different functional states are rare. Recently, we created a magnetically responsive surface that can reversibly switch between slippery and pinning states similar to the pitcher plant surface when it is wet and dry, respectively. Such a surface was fabricated by self-assembly of a soft magnetic pillar array that carries magnetic dipole and responds to an external magnetic field reversibly. By using such magnetic carpets, we were able to transport solid non-magnetic cargos effectively. In addition, we were able to transport water droplets on the surface by dynamic programming of the pinning and slippery locations/patches on the surface. We will exploit such pillars in microfluidic channels to obtain local pumps that induce flow and mixing with spatial freedom and precision. Programmable fluid collection, transport, and controlled mixing and un-mixing of liquids in Newtonian/ or non-Newtonian liquids may potentially allow for unprecedented bio-medical capabilities in microfluidic and millifluidic devices.

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Project ID	**URI P21-19_Vanni**
Project title	**Improving the design of self-assembling artificial water channels**
Research group	Prof. Stefano Vanni https://www3.unifr.ch/bio/en/research/bioinformatics/vanni.html
Host Institution	Department of Biology, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

In the last decade, recent advances in material sciences allowed generation of bio-inspired water transmembrane channels with potential applications in water desalination processes. In particular, artificial imidazole quartets (I-quartets) have been shown to generate self-assembling aquaporin-like channels of ca. 2.6 Å diameter with selectivity against ions. These type of supramolecular structures could have a large impact in the de-novo design of artificial water desalination filters. However, self-assembly mechanisms and principles of such supramolecular structures are not yet completely understood, leaving “plenty of room at the bottom” for optimization and design of new channels.

Computational techniques offer a perfect high-throughput and affordable tool for the design of these systems, providing insights in the atomic details of these processes. In this project, we will take advantage of the long time-scales of coarse-grained molecular dynamics simulations (CG-MD) to study how molecular properties of both channel-forming molecules (e.g. HC8, S-HC8, R-HC8) and lipid membranes influence self-assembly, stability and geometry of the formed channels.

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Project ID	**URI P21-20_Weder**
Project title	**Cephalopod-inspired mechano-reporting polymeric materials**
Research group	Prof. Christoph Weder https://www.ami.swiss/en/groups/polymer-chemistry-and-materials/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Cephalopods such as octopus, squid, and cuttlefish can drastically and dynamically alter their appearance for camouflage and signaling, thanks to an array of responsive dermal structures which manipulate light via two distinct mechanisms. These structures include pigment-containing chromatophores, which absorb certain wavelengths of light, and nano-structured iridophores, which reinforce or cancel out certain wavelengths.

Inspired by this dual mode coloration system, we will prepare polymeric materials that visualize mechanical deformation with two separate optical read-outs, one absorptive and the other photonic. Such a mechano-sensor could be used to investigate broad distributions of local strains and stresses around heterogeneities, such as cracks. The summer student will be involved in the synthetic preparation of the materials, spanning organic, polymer and colloid synthesis, and their mechano-optical characterization.

UNDERGRADUATE SUMMER RESEARCH INTERNSHIPS
National Center of Competence in Research for Bio-Inspired Materials

Research Projects Summer 2021

Project ID	**URI P21-21_Weder**
Project title	**Bio-inspired mechanically morphing and stimuli responsive composites**
Research group	Prof. Christoph Weder https://www.ami.swiss/en/groups/polymer-chemistry-and-materials/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only period II: 15 June - 15 September**

Project summary

The desert resurrection plant curling up to protect itself from harmful radiation or the passive opening of pine cones upon drying are typical examples found in nature of how an organism can respond to an external stimulus. [1] Synthetic stimuli responsive polymeric materials can respond in a predefined way to an applied stimulus such as temperature, moisture, light or mechanical stress. Popular examples are self-healing, shape memory and mechanochromic materials. [2]

Within the scope of this project, novel stimuli responsive and mechanically morphing polymer materials with specifically tailored properties are developed to fabricate electro-thermal controlled bilayer bending actuators for deployment in soft robotic systems. [3]

The summer research intern will contribute to this interdisciplinary project related to his background and will learn from synergetic collaborations with different research fields. Creativity and out of the box thinking are highly beneficial for this project.

[1]: Montero L. et al. https://doi.org/10.1021/acs.chemrev.7b00168

[2]: Herbert K.M. et al. https://doi.org/10.1021/acs.macromol.7b01607

[3]: Muff L.F. et al. https://doi.org/10.1002/aisy.202000177

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Research Projects Summer 2021

Project ID	**URI P21-22_Weder**
Project title	**Light-responsive polymersomes for light-triggered release**
Research group	Prof. Christoph Weder https://www.ami.swiss/en/groups/polymer-chemistry-and-materials/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	12 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

Polymersomes are hollow, spherical structures formed through the self-assembly of diblock copolymers comprising a hydrophilic and a hydrophobic block. They are very promising for a variety of applications such as nanoreactors, cell mimics, and drug carriers. Especially for the latter, the release of cargo in a spatially and temporarily controlled manner is of great interest: light-responsive polymersomes that would encapsulate and protect their cargo until they reached the area of release are ideal candidates for drug delivery systems. Challenges in this field include the development of block copolymers that are light-responsive in the visible and (near-)infrared range as well as the encapsulation efficiency of such polymersomes. In this project, novel light-responsive moieties will be developed and used to functionalise block copolymers. The summer student will be involved in (i) the synthesis of light-responsive moieties and block copolymers, (ii) the self-assembly of such functional diblock copolymers into polymersomes, (iii) their characterisation by means of NMR, microscopy, light scattering, etc., and (iv) measuring the light-triggered release of drug model compounds from the polymersomes.

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Research Projects Summer 2021

Project ID	**URI P21-23_Weder**
Project title	**Mechanochromic loopy structures based on weak dye interactions**
Research group	Prof. Christoph Weder https://www.ami.swiss/en/groups/polymer-chemistry-and-materials/
Host Institution	Adolphe Merkle Institute, University of Fribourg
Duration	8 weeks
Possible period	**Only Period II: 15 June - 15 September**

Project summary

The hierarchical assembly observed in Nature serves as a blueprint for the design of artificial materials with unique properties. For example, the genetic information of all organisms is encoded in the DNA and one strategy to regulate the activation and suppression of individual genes is DNA looping. Thus, a DNA loop is formed when two proteins bind to different DNA sites and form a non-covalent complex. Inspired by the example of natural loop-type structures, the objective of this project is the synthesis of a loop structure which covalently links fluorescent dye pairs. The dyes thereby act as weak binding motifs and control the self-assembly of the structure into a loop. Embedding the loop structure into polymers and applying stimuli such as temperature or mechanical force triggers the dissociation of the dye pairs, which causes a fluorescence intensity increase or a color change.

The summer student will be involved in the project by 1) the synthesis of novel loop structures and their incorporation into polymers 2) the evaluation of the mechanical and mechanochromic properties of the polymers in solution and the solid-state by means of fluorescence spectroscopy and tensile testing.

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