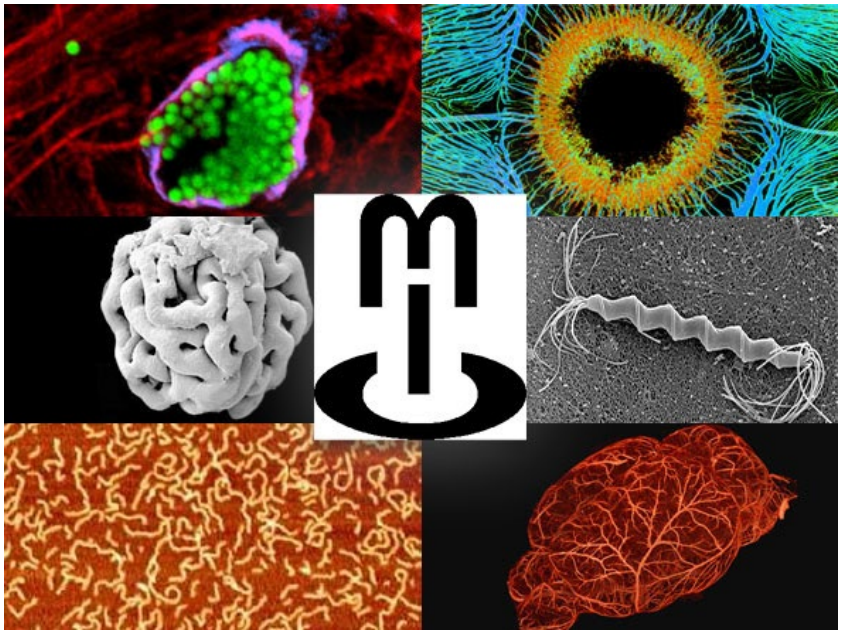
Bern, June 26, 2024
MIC Research Day 2024
Abstract Booklet

UNIVERSITÄT BERN

Faculty of Medicine
Faculty of VetSuisse
Faculty of Science
Microscopy Imaging Center (MIC)



MIC Research Day 2024

Abstract Booklet

Date: Wednesday, June 26, 2024
09:30 am – 04:00 pm

Location: DCBP U113, Freiestrasse 3, 3012 Bern

Webpage: https://www.mic.unibe.ch/events/mic_research_day/

Organized by the Microscopy Imaging Center (MIC)
of the University of Bern

The MIC Research Day is part of the educational program of the Cutting Edge Microscopy (CEM) PhD specialization.

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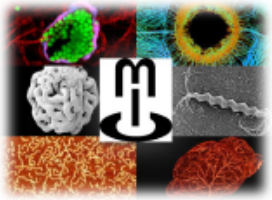
Microscopy at University of Bern is coordinated and administered by the **Microscopy Imaging Center** (MIC, https://www.mic.unibe.ch/). The Microscopy Imaging Center is the University of Bern's center of excellence for high-end microscopy in the life sciences. The mission of the MIC is to consolidate expert knowledge and provide technical support in microscopy at the University of Bern. MIC coordinates visibility of and access to the microscopic instruments. MIC provides teaching on Master and PhD level and offers training for scientific staff at all levels. MIC contributes fundamentally to the curriculum of the PhD specialization program Cutting Edge Microscopy (CEM). Services of the MIC concern image analysis, large image data volume handling and processing, sample preparation and introduction into microscope operation. Yearly highlights of the MIC are the MIC Research Day, the MIC Summer School and the MIC Symposium.

The **MIC Research Day** is the MIC's annual networking event for scientists at the University of Bern. It brings together scientists who use microscopy with other interested researchers who want to use microscopy. Young scientists and established researchers present data from their exciting research projects. Scientists from other universities and from the research-oriented industry are cordially invited to take part in the MIC Research Day.

MIC thankfully acknowledges financial support of the MIC Research Day 2024 by:

The PhD Program *Cutting Edge Microscopy*

and our sponsors from industry



Research Day
of the
Microscopy Imaging Center

Wednesday, June 26, 2024, from 09:30 to 16.00
DCBP U113, UniBE, Freiestrasse 3, 3012 Bern

UNIVERSITÄT BERN

09:30	**Registration and Coffee**	
10:00	Welcome, MIC board	**The MIC - from the beginnings to the latest highlights**
10:10	**Peter Gehr** *Institute of Anatomy*	How microscopy became a university affair
10:25	Session 01, introduction	The power of light microscopy in very different applications.
10:30	**Li Xin** *Theodor Kocher Institute*	Using Near-Infrared imaging to assess the cerebrospinal fluid flow in EAE animal model
10:50	**Isabel Schultz-Pernice** *Institute of Virology and Immunology*	Elucidating mpox virus neurovirulence mechanisms with advanced imaging techniques and 3D organoids
11:10	**Saiko Yoshida** *Institute of Plant Sciences*	Quantitative image analysis of plants from cells to organs
11:30	**Nicholas James Desnoyer** *University of Zurich*	Capturing Plant Development at Scales
11:50	**Lindsay Bussau** *Optiscan Imaging Ltd*	Application of in vivo confocal laser endomicroscopy and its feasibility in routine diagnosis of surgical cancer specimens
12:00	**Lunch & Meet experts of the MIC**	
13:00	Session 02, introduction	Structural analysis: Computer tomography and electron microscopy
13:05	**Oleksiy-Zakhar Khoma** *Institute of Anatomy*	Micro(angio)CT in preclinical dental research
13:25	**Alicia Borgeaud** *IBMM*	The behaviour of Apaf1 in apoptotic cells unveil apoptosome organization and dynamics in vivo.
13:45	**Divyansh Gautam** *DCBP*	Structural and Compositional Insights on Alloy Nanoparticles used in Electrocatalysis by ElectronMicroscopy
14:05	**PhD *Cutting Edge Microscopy***	Highlights of the last 12 months
14:10	**Dimitri Vanhecke**, UniFR	MIC Symposium 2024 «BioInspired Materials», 15 Nov 2024
14:15	**Coffee and Networking**	
14:45	**Arne Seitz,** *EPFL & LS²*	LS² Intersection Microscopy
14:55	Session 03, introduction	Live cell imaging and advanced image analysis
15:00	**Matias Preza** *Institute of Parasitology*	Parasites in focus, understanding tapeworm biology and how to make their life complicated
15:20	**Reto Lang** *Institute of Virology and Immunology*	Investigating the role of (stress) granules during virus infections
15:40	**Benjamin Towbin** *Institute of Cell Biology*	Growth control from cells to organisms: live imaging across scales
16:00	**Farewell**	

The MIC Research Day 2024 is accredited for 0.5 days of continued education in animal experimentation in the Canton of Bern

Supported by

PhD specialization program
"Cutting Edge Microscopy"

Registration

Organized by:
Microscopy Imaging Center (MIC)
A Core Facility of the University of Bern with active participation of the Faculty of Medicine, the Faculty of Science and the Vetsuisse Faculty.

Using Near-Infrared imaging to assess the cerebrospinal fluid flow in EAE animal model

Li Xin, Adrian Madarasz, Daniela Ivan, Simone Aleandri, Paola Luciani, Giuseppe Locatelli, Steven T. Proulx

Theodor Kocher Institute, University of Bern, Bern

Multiple sclerosis (MS) is a debilitating autoimmune disease of the central nervous system. Many of the currently used drugs for MS have been developed, tested or validated by using experimental autoimmune encephalomyelitis (EAE), the most commonly used animal model of MS. Whereas MS is a demyelinating disease impacting both brain and spinal cord, EAE animals are generally recognized to develop ascending motor deficits with lesions largely localized in the spinal cord with yet unknown reason. Despite the knowledge that CSF circulation and drainage are essential features to maintain homeostasis within the central nervous system, the impact of CSF flow in the context of MS/EAE have been largely overlooked. We attempt to comprehensively map CSF flow at multiple EAE disease phases using dynamic in vivo near-infrared (NIR) imaging of the spinal cord and superficial cervical lymph nodes of EAE mice. Our study demonstrated a significantly impaired spinal CSF flow within the subarachnoid space prior to disease onset, which persisted until peak stage and was partially recovered at the chronic remission phase. Interestingly, cranial CSF efflux to cervical lymph nodes remain functional during EAE. Histopathological examinations by wide-field and confocal microscope on decalcified cranial and spinal tissue revealed that substantially reduced CSF circulation coincided with the presence of infiltrating CCR2+ myeloid cells in the leptomeningeal space of the sacral spinal cord before EAE onset, whereas recovery of CSF circulation occurred in parallel with significantly reduced CCR2+ cell infiltrates. Moreover, nasal lymphatics presumably respond to changes in CSF flow by showing significantly larger area covered by LYVE+ lymphatic vessels and the ability of draining CCR2+ immune cell infiltrates. It is our hypothesis that resolution/remission of neuroinflammation is dependent of intact clearance routes and that stimulation of CNS clearance (and thus CSF flow) may represent a promising clinical strategy.

Elucidating mpox virus neurovirulence mechanisms with advanced imaging techniques and 3D organoids

Isabel Schultz-Pernice[1,2,3], Amal Fahmi[1,2,3], Yen-Chi Chiu[4,5], Blandina I. Oliveira Esteves[1,2], Teodora David[1,2], Antoinette Golomingi[1,2], Beatrice Zumkehr[6], Damian Jandrasits[7], Roland Züst[7], Selina Steiner[8], Carlos Wotzkow[8], Fabian Blank[8,9], Olivier Engler[7], David Baud[4,5], and Marco P. Alves[1,2,10]

[1]Institute of Virology and Immunology, [2]Department of Infectious Diseases and Pathobiology, [3]Graduate School for Cellular and Biomedical Sciences, [6]Department of BioMedical Research, [8]Department for BioMedical Research, [10]Multidisciplinary Center for Infectious Diseases, University of Bern, Bern. [4]Materno-Fetal and Obstetrics Research Unit, Department Woman-Mother-Child, Lausanne University Hospital, Lausanne. [5]Faculty of Biology and Medicine, University of Lausanne, Lausanne. [7]Spiez Laboratory, Spiez. [9]Department of Pulmonary Medicine, Inselspital, Bern University Hospital, Bern.

Early in May 2022, first cases of mpox virus (MPXV) infection without traceable contact to African population or fauna were reported in UK. Since then, 113 countries registered cases of infection, marking the largest outbreak outside of endemic regions. First manifestations of mpox include fever, lymphadenopathy, and muscle aches, followed by vesiculopapular rash development. Neurological manifestations, ranging from mild headache to fatal encephalitis, may develop in around 3% of patients. MPXV DNA and MPXV-specific IgM antibodies were detected in the cerebrospinal fluid of encephalitis patients, suggesting neuroinvasive potential of MPXV. Using human neural organoids (hNOs) we explored the susceptibility of cerebral tissue to infection with a patient-derived 2022 isolate of MPXV. MPXV efficiently replicates in hNOs as indicated by the exponential increase of viral loads upon infection and the elevated frequency of MPXV-positive cells over time. Transmission electron microscopy imaging of infected hNOs confirmed the presence of mature viral particles as well as perinuclear viral factories. Through confocal immunofluorescence analysis we observed susceptibility of different cell types to the virus, including neural progenitor cells and neurons. Furthermore, we detected the presence of viral antigen in neurites and in foci of grouped cells distributed throughout the tissue. In line with this, comparing released and cell-associated MPXV titers, we observed significantly more cell-associated infectious virus, spanning over several orders of magnitude, suggesting spread of MPXV by cell-to-cell contact. While hNOs displayed no evident outer morphological changes upon infection, confocal microscopy imaging allowed the detection of MPXV-harboring varicosities on neurites, pointing to viral manipulation of axonal transport and neuronal injury. In accordance, the apoptosis marker cleaved caspase-3 was detected within neurite swellings. Our findings underline the value of hNOs to model neurotropic virus infection in the human host and identify a mechanism potentially contributing to MPXV-mediated neuropathology.

Quantitative image analysis of plants from cells to organs

Saiko Yoshida[1], Roxane Spiegelhalder[1], Richard Smith[2], Michael Raissig[1]

[1]Institute of Plant Sciences, University of Bern, Bern (CH)
[2]The John Innes Centre, Norwich Research Park, Norwich (UK)

How do multicellular plants build their form? Plant cells are surrounded by rigid cell walls that restrict their mobility. Therefore, shape of plants is controlled by coordinated patterns of cell division and cell growth. Understanding the molecular mechanisms that regulate plant shape requires high-resolution imaging and quantitative imaging data analysis at the cellular level. In recent years, great advances in the abilities of laser scanning fluorescent microscopy and quantitative image analysis in plant science have made it possible to observe spatial-temporal dynamics during morphogenesis at cellular level. In my talk, I will present recent protocols to perform multidimensional and quantitative image analysis of plant cells. I will show how to prepare fixed and live specimens of various plant materials for observation of laser scanning fluorescent microscopes, and how to acquire 3D imaging or 4D time-lapse imaging of plant cells. I will also introduce examples of quantitative data analysis using the software called MorphoGraphX[1,2,] as an example of a widely used software within the plant research community.

[1] Barbier de Reuille et al (2015) MorphoGraphX: A platform for quantifying morphogenesis in 4D, Elife

[2] Strauss et al (2022) Using positional information to provide context for biological image analysis with MorphoGraphX 2.0, Elife

Capturing plant development at scales

Nicholas James Desnoyer

Department of Plant and Microbial Biology, University of Zurich, Zurich (CH)

Plants are ideal specimens for imaging; they are sessile, autotrophic organisms whose entire development can be captured with microscopy. With the exception of protoplasts, all live imaging on plants, from macroscopic to single molecule, is performed on intact or dissected living tissues and is therefore placed in the context of the organism at some scale. The biological questions at these scales which plant researchers address can often be answered most accurately through live imaging setups that present unique imaging challenges. Overcoming such challenges requires flexibility in the imaging systems employed, ensuring that the microscope and specimen are tailored using the least invasive approach possible. In this talk, the importance of creativity and the establishment of minimally-invasive setups for live imaging of plants will be emphasized, using examples of timelapse microscopy at various scales. Finally, a perspective on the future of live imaging in plants will be discussed.

Application of in vivo confocal laser endomicroscopy and its feasibility in routine diagnosis of surgical cancer specimens

Lindsay Bussau

Optiscan Imaging Ltd, Melbourne (AU)

Background: There is a need for real time intraoperative assessment of microscopic structures to provide surgeons with additional information to assist them in procedures such as resection of cancerous tumours and determination of tumour margins.
Material & Methods: In this study, a hand-held fluorescence-based confocal laser endomicroscope (CLE) with 0.55 µm lateral resolution and 5.1µm lateral resolution (ViewnVivo®, Optiscan Imaging Ltd, Australia) was used to image freshly excised breast tumours and fixed breast tumour slices to enable correlation of live confocal images with standard histopathology on the same tissue. Fresh breast tumours were stained with 0.01% acriflavine hydrochloride immediately following resection and the outer surface of the tissue was imaged prior to formalin fixation and processing according to standard pathology protocols. During cut-up, representative tissue slices obtained through the centre of the tumour were again stained with 0.01% acriflavine hydrochloride and imaged around the outer surface edge, around the tumour margin, and at the tumour core. Video recording of CLE imaging was performed to enable correlation of the microscopic data with the region of interest on standard haematoxylin & eosin prepared tissue samples. CLE images of different tumours and margins including fresh and fixed tissue were compared to standard histopathology.
Results: Interim readout on fixed and processed breast tumour and margin samples shows that the Optiscan platform can provide images comparable to conventional histopathology for determination of presence of cancer and for determination of tumour involvement in surgical margins. This was possible in all 15 resected tumours which underwent fixation, with final diagnoses including invasive lobular carcinoma and invasive carcinoma NST. Additionally, Optiscan CLE could identify and differentiate healthy marginal tissue from cancer-involved margins in each case that was identified on gross sectioning and on final definitive histopathology. Assessment of fresh tissue produced excellent imaging quality. Fixation did not negatively affect quality of imaging compared to that of fresh tissue. Importantly, imaging could be achieved bedside or in the pathology lab.
Conclusion: CLE imaging of fresh breast cancer tissue and formalin fixed tissue slices showed excellent correlation with cytological and architectural features noted on histopathological slides of corresponding breast tumour tissues. This study demonstrates the feasibility of using CLE imaging on freshly excised tissue and its ability to provide near-immediate assessment of breast cancer tissues and tumour margins.

Micro(angio)CT in preclinical dental research

Oleksiy-Zakhar Khoma

Institute of Anatomy, University of Bern, Bern (CH)

600 million people in developed world are affected by tooth loss, from which around 20-50% are treated with tooth implants. Bacterial infections, that can be caused by suboptimal soft tissue integration, are contributing to failure of this treatment in up to half of the patients. Research of this problem requires a toolbox for assessment of peri-implant mucosa health. According to our knowledge, there are no established methods or protocols for 3D-visualization and analysis of the peri-implant vascularization of neither the bone nor the soft tissue. MicroangioCT provides a platform to fill this gap. For this study, five minipig jaws were perfused with the polymer-based contrast agent µAngiofil. Ten hemimandibles were harvested, each containing four dental implants. Acquired samples were first scanned at an overview resolution of 20µm using SKYSCAN 2214 X-ray nanotomograph. Consequentially, each individual implant surrounded by soft and bone tissue was dissected for mid (20µm) and high (5µm) resolution scanning. Acquired datasets provided the possibility for a qualitative as well as future quantitative analysis of the peri-implant vasculature. Initial data analysis using ilastik machine learning toolkit provided an insight into quality of vascularization differences based on the soft tissue vasculature density in the close vicinity of the implants. However, due to the nature of the microCT scanning of metal objects, artefacts are observed that challenge the vascular segmentation process. These issues have the possibility to be overcome by certain computer vision algorithms that have shown substantial success in other biomedical imaging fields. One of such algorithms is a fully convolutional neural network with U-net architecture, which showed a possibility of improving the segmentation to be feasible.

The behaviour of Apaf1 in apoptotic cells unveil apoptosome organization and dynamics in vivo

Alicia Borgeaud[1,2], Iva Ganeva[1,2], Amandine Stoss[2], Daniela Ross-Kaschitza[2], Calvin Klein[2], Liyang Wu[3], Thomas Kaufmann[3], Wanda Kukulski[1,2]

[1]Medical Research Council Laboratory of Molecular Biology, Cambridge (UK), [2]Institute of Biochemistry and Molecular Medicine, University of Bern, Bern (CH), [3]Institute of Pharmacology, University of Bern, Bern (CH)

During programmed cell death, cytochrome c is released from the mitochondrial cristae into the cytoplasm. There, cytochrome c interacts with cytosolic Apaf1, resulting in the formation of a heptameric caspase activation platform called the apoptosome complex. While the apoptosome is well characterized in vitro, its formation and function in vivo remain unclear. Using a combination of light and electron microscopy approaches, we addressed the spatiotemporal dynamics of Apaf1 distribution, structure, and function inside cells. We discovered that in apoptotic HeLa cells, Apaf1 accumulates into multiple cytosolic foci prior to cell death. Foci disappear within a few hours of their appearance when cell death does not occur, suggesting that their dynamics relate to caspase activity. We hypothesised that these foci might be sites of apoptosome formation. We found that cytosolic presence of cytochrome c is required for Apaf1 foci formation. However, its binding to Apaf1 seems transient, contrary to what in vitro work suggested previously. We also observed that Caspase-9 is required for Apaf1 foci formation. By studying Apaf1 mutants, we found that the mechanism of foci assembly is reminiscent of apoptosome formation described in vitro. Thus, we suggest that Apaf1 foci functionally correspond to the apoptosome and are implicated in caspase activation, with transientness as a possible additional level of regulation. Using different correlative microscopy approaches, including cryo-electron tomography, we investigated the structural organisation of Apaf1 assemblies directly in their cellular context. These data indicate that Apaf1 foci consist of large, higher-order irregular assemblies that differ in ultrastructure from the wheel-like structure of the apoptosome previously described in vitro. Our findings suggest that the apoptotic activity of Apaf1 may be locally controlled and regulated through its structural organisation into foci, representing an unexpected level of complexity.

Structural and Compositional Insights on Alloy Nanoparticles used in Electrocatalysis by Electron Microscopy

Divyansh Gautam[1], Nicolas Schlegel[2], Gustav K.H Wiberg[1], Jonathan Quinson[2], Espen Drath Bøjesen[3], Matthias Arenz[1]

[1]Department of Chemistry, Biochemistry and Pharmaceutical Sciences, University of Bern, Bern (CH), [2]Department of Chemistry, University of Copenhagen (DK), [3]Department of Biological and Chemical Engineering, Aarhus University, Aarhus (DK), [4]Interdisciplinary Centre of Nanoscience, Aarhus University, Aarhus (DK)

Seeing is believing and that's where Electron Microscopy has helped in understanding nanoscale structures. Nanoscience has multiple disciplines providing practical solutions for the current energy demands. Electrocatalysis is one of the fields that get complementary benefits from Electron Microscopes while looking for renewable ideas. Nanoparticles based electrocatalyst play a key role in improving kinetics in electrocatalysis by offering a higher surface to volume ratio than bulk samples.
In our current research we are looking at metallic nanoparticles which have multielement compositions. The multiple principal elements, commonly referred as High Entropy Alloys (HEAs), in the nanoparticles provide a platform to optimize the catalyst based on sensitivity, stability and selectivity aspects of a particular electrochemical reaction. However, with multiple elements come structural and compositional complexity which can be characterized readily by Transmission Electron Microscopy. Preferentially, Scanning Transmission Electron Microscopy (STEM) facilitates atomic resolution enabling the observation of the local ordering and segregation in disordered structures like HEAs.
STEM being atomic scale precision technique yields extensive dataset from the real and reciprocal space. Consequently, advance data analysis techniques like non-negative matrix factorization prove invaluable in analyzing the hyperspectral dataset collected from STEM. My objective is to find a correlation of structure and property (sensitivity and stability of catalysts) in context of electrocatalysis, leveraging scattering techniques.
In my presentation at MIC research day, I aim to demonstrate our workflow to study catalysis while using electron microscopy.

Parasites in focus, understanding tapeworm biology and how to make their life complicated.

Matias Preza

Institute of Parasitology, University of Bern, Bern (CH)

Parasitic flatworms, more specifically tapeworms, are parasites that have very complex life cycles including several hosts. Tapeworms can infect a big variety of animals, including farm animals and humans, thereby causing disease. Some of these diseases can be very serious, as is Alveolar Echinococcosis (AE), caused by infection with the fox tapeworm Echinococcus multilocularis. Therapeutic options for AE are limited, surgery is the best choice (when possible), and drug treatment is very limited, and not always effective. For all these reasons, new and better strategies against AE are urgently needed.

In our group we use in vitro and in vivo based approaches to better understand the biology of tapeworms, with a focus on the genus Echinococcus. We have developed specialized tests to screen large numbers of compounds in whole-organism based approaches to identify new promising compounds against tapeworms.

The focus of this talk will be on our microscopy-based methods: One of these tests is a motility-based screening, and it is based on automatic acquisition of images in motorized life-cell imaging microscopes. This test allows us to detect compounds which inhibit the motility of parasites. Another approach assesses the impact of single nutrients on in vitro parasite growth and it is based on image analyses. Furthermore, we have developed a microscopy-based method to quantify infection levels in mice with AE and like this assess the effects of new drug therapies in vivo. This method allowed us to drastically decrease the number of mice used in each experiment. Finally, we also use electron microscopy to identify alterations in the ultrastructure of the parasite after drug treatment.

Thus overall, a variety of microscopy-based tools allow us to study Echinococcus and bring us closer to new ways for disease treatment.

Investigating the role of (stress) granules during virus infections

Reto Lang[1,2,3], Silvio Steiner[1,2], Jenna Kelly[1,2,4], Anne-Christine Uldry[5], Pratik Dave[6], Sophie Braga-Lagache[5], Jeffrey Chao[6], Manfred Heller[5] and Volker Thiel[1,2,4]

[1]Institute of Virology and Immunology (IVI), Bern and Mittelhäusern (CH), [2]Department of Infectious Diseases and Pathobiology (DIP), Vetsuisse Faculty, University of Bern, Bern (CH), [3]Graduate School for Cellular and Biomedical Sciences, University of Bern, Bern (CH), [4]Multidisciplinary Center for infectious Diseases (MCID), University of Bern, Bern (CH), [5] Department for BioMedical Research (DBMR), University of Bern, Bern (CH), [6]Friedrich Miescher Institute for Biomedical Research (FMI), Basel (CH)

Stress granules (SGs) are membraneless accumulations of ribonucleoproteins which form in the cytosol of eukaryotic cells upon exposure to a variety of stress stimuli. These granules are proposed to store untranslated mRNA during stress situations and support the dynamic reprogramming of translation towards stress resolving pathways. Growing evidence of many viruses specifically interfering with SG formation, and the identification of antiviral sensor and effector proteins in SGs, suggests an involvement of these condensates in the antiviral host response. However, the characteristics of virus-induced SGs are poorly understood.

Our lab previously showed that SGs induced by the model coronavirus mouse hepatitis virus (MHV) have distinct characteristics from canonical SGs. To assess if these are general features of virus-induced SGs, we expanded our analysis to the Semliki Forest virus (SFV), another RNA virus known to induce SGs. By using live-cell fluorescence microscopy based on a GFP-tagged SG protein stably expressed in cells, we assessed the formation of the highly dynamic SGs during the time course of MHV and SFV infection. Quantification of SGs done with an image post-processing workflow based on Fiji and Ilastik, revealed vastly distinct time points of SG induction between the two investigated viruses in the context of their replication cycle. To compare the composition of virus-induced SGs, we further analysed the subcellular localization of several SG markers and viral RNA using indirect immunofluorescence and fluorescence in-situ hybridization. Our data displayed a virus-specific abundance of certain components between MHV- and SFV-induced granules. A comprehensive identification of the SG proteome by proximity-dependent biotinylation and quantitative proteomics further revealed profound differences in the SG protein composition between the two viruses.

Taken together, our findings revealed different aspects of virus-induced granules to be strongly virus-specific, likely reflecting different roles of these condensates during MHV and SFV infections.

Growth control from cells to organisms: live imaging across scales

Benjamin Towbin

Institute of Cell Biology, University of Bern, Bern (CH)

During development, different organs must reach their correct size, as deviations from correct organ size proportions can lead to severe disease or organismal malfunction. However, reaching the correct proportions is challenged by the tendency of exponentially growing systems to amplify small deviations in the growth rate to large deviations in the size. Our laboratory asks how such organ size divergence is prevented by the coordination of the growth of different body parts with each other. Using quantitative live imaging of the nematode C. elegans over its entire development, we track the growth of individual organs over time to determine how deviations in organ size are dynamically corrected. I will present our latest published and unpublished research on the molecular factors involved in this control and on live imaging technologies we use to monitor organ growth at high throughput and across scales from molecules to the entire animal.