NEWSLETTER 29th edition | Summer 2019

IST AUSTRIA
Institute of Science and Technology
10 YEARS

Foreword

Almost ten years ago, IST Austria embarked on a path towards the ambitious goal of becoming a beacon for scientific excellence in Austria and the world. Back then, the campus comprised a renovated office building for theoretical science, the Raiffeisen Lecture Hall, and the voestalpine Building for the administration. Over the years, the infrastructure has expanded to include three new laboratory buildings for experimental science, two scientific facility buildings, and a second administration building.

The growth in campus infrastructure reflects the growth in the number of scientists and staff at IST Austria. In June 2009, 37 employees started work on campus, with four professors among them. Since then, the faculty has increased to 52 professors. Currently, 16 professors conduct research in mathematics and computer science, 26 focus on the life sciences, and 10 specialize in physics and chemistry. By 2026, the number of employees will exceed 1000, including about 90 research groups.

2019 marks a year of celebration for us. We will kick off our festivities with the "Open Campus" on May 26. Our annual science festival for the general public will be followed by "10 Years of IST Austria", a festive event on June 4 with a keynote lecture by CEU President and Rector Michael Ignatieff and a panel discussion on "Science and Society: A Rewarding Partnership?" An IST Lecture by Nobel laureate Paul Nurse on June 5 and an ÖAW-IST Lecture by the Director of the Max Planck Institute for Intelligent Systems Bernhard Schölkopf on June 6 will round off our anniversary celebrations.

Thomas A. Henzinger | President, IST Austria

Open Campus: join our annual science festival on May 26

The Open Campus, the annual science festival for families, will be held on May 26 from 12:00pm to 6:00pm at IST Austria in Klosterneuburg. This year, IST Austria will take its 10-year anniversary as an opportunity to dip into the past and look into the future: The science festival will start with a huge birthday party in the Raiffeisen Lecture Hall. The award ceremony of the school competition "Wir schaffen Zukunft" will be followed by the family lecture "Mikroskope: Winzige Körperzellen – ganz groß!", and Vince Ebert's science comedy "Zukunft is the Future".

The program of the Open Campus will include a variety of science activities for children and adults. A hands-on exhibition will present research questions pursued by IST Austria scientists on campus. Guided tours to labs and scientific service units will provide interesting glimpses behind the scenes of the research institute. A starch pool and a research game will be fun activities for everybody.

Professor Leonid Sazanov elected as Fellow of the Royal Society

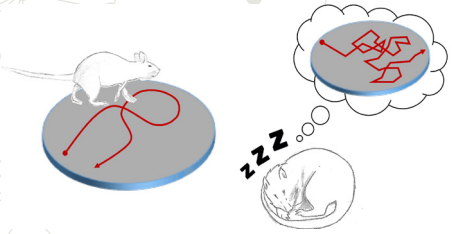
The Royal Society, the national Academy of Sciences in the UK, has elected IST Austria Professor Leonid Sazanov as a member of their Fellowship. According to the Royal Society, the structural biologist was chosen for "advancing understanding of the structure and mechanism of the respiratory enzyme NADH: ubiquinone oxidoreductase, (complex I). His efforts have opened the door for understanding the bases of a range of human diseases arising from mutations in complex I."

Sazanov explores structure and function of large membrane protein complexes from the domain of bioenergetics. Using the bacterial enzyme as a model, he discovered the first atomic structure of respiratory complex I, an entry point into the respiratory chain. This redox chain of enzymes is responsible for most of the energy production in the cell. He also determined the first complete atomic structure of the even larger mammalian mitochondrial complex I, using new cryo-EM methods.

10 Years of IST Austria: festive event on June 4

A festive event will be held in the Raiffeisen Lecture Hall on June 4 to celebrate the 10-year anniversary of IST Austria. The event will start at 6:00pm with welcome words by IST Austria President Thomas A. Henzinger and the Federal President of the Republic of Austria Alexander Van der Bellen. Short interviews with Federal Chancellor of Austria Sebastian Kurz, Federal Minister of Education, Science and Research Heinz Fassmann, and Governor of Lower Austria Johanna Mikl-Leitner will follow before Rector and President of the Central European University Michael Ignatieff will give a keynote lecture about "Science in Challenging Times".

A panel discussion on "Science and Society: A Rewarding Partnership?" with the participation of Former President of the Institut Pasteur Alice Dautry, EMBL Director General Edith Heard, President of the Weizmann Institute of Science Daniel Zaifman, Michael Igantieff, and Thomas A. Henzinger as moderator will conclude the festive event.

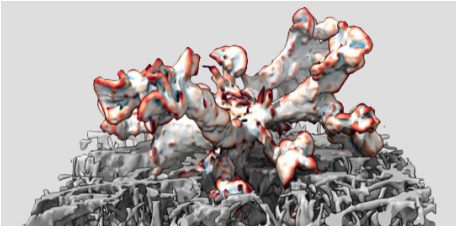


Memories of movement are replayed randomly during sleep

Sleep is far from being an inactive time for the brain: while rats are asleep, neurons in the hippocampus fire rapidly. After a rat has repeatedly moved from one spot to another, the same neurons that fired while the rat as moving "replay" this firing while the rat is asleep. Previously, it was thought that replay patterns only correspond to trips rats had made repeatedly while awake. In their study published in Neuron, Postdoc Federico Stella and Professor Jozsef Csicsvari at IST Austria show that when rats roam around freely, the hippocampus replays during sleep, but it does so in a random manner that resembles the famous Brownian motion known from randomly moving particles.

Place cells are cells in the hippocampus that fire when the rats are in a certain location. In order to form a memory, to be able to recall the location and make a decision, they need to replay the firing pattern during sleep. The replay is easy to see in the data and happens at a fast pace. Previous studies focused on replay after rats visited locations in a maze in a certain order. They found that the order in which place cells fire corresponds to the rat's movement, and this replay pattern was also observed during sleep. In the new study, Csicsvari and Stella instead investigated what happens when a rat moves through an open field environment, like a box. The researchers let the animals run around the environment while they dropped food rewards randomly, all the while recording how up to 400 place cells fire at the same time. They then recorded how the same place cells fired while the rat was asleep.

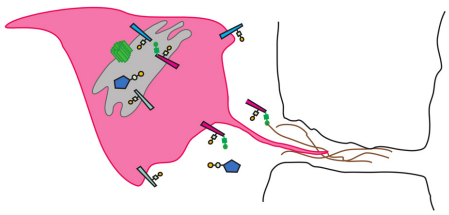
What they found was unexpected, Csicsvari says. "Neurons fire in places the rat has explored, but the place sequence expressed by the firing follows random trajectories. Surprisingly, these random trajectories are similar to Brownian motion, the random movement seen when particles move, collide and change direction."



Leukocytes use nucleus as ruler to choose path of least resistance

Certain cell types continuously crawl through the body to reach their place of action. For instance, all leukocytes in the human body cover a cumulative distance of more than 100,000 km per hour. Their amoeboid way of movement that allows them to move around 100 times faster than other cell types. How these extremely fast cells navigate through the dense meshwork of interstitial connective tissue fibers without harming other cells has been of great interest to cell biologists. In their study published in Nature, Professor Michael Sixt and his team—including first author Jörg Renkawitz, Postdoc at IST Austria at the time of the study and now leading his own research group at the Biomedical Center of Ludwig-Maximilians-University in Munich—have found out how leukocytes manage to choose the path of least resistance when navigating through complex environments.

To understand the mechanism behind this selective form of cell movement, the researchers built an obstacle course for leukocytes in reconstituted tissue where the cells could choose between differently sized pores while following global directional cues. What they observed was that whenever the amoeboid cells had a choice, they used the bigger pores, i.e. the path of least resistance. In further tests, the scientists found that the cells facilitate this active directional movement by pushing their nucleus to the front of the cell so it can serve as a kind of mechanical gauge or ruler. In other words, as the cell is moving forward, it applies cytoskeletal forces to insert its nucleus into several adjacent pores to measure pore sizes. "The usual organelle to steer a cell is the actin rich leading front, which explores the environment. Unexpectedly, we found that this is not what determines the path of a leukocyte. Instead, it is the nucleus that guides the cell through the bigger pores. This makes sense as the nucleus is the most bulky part of the cell and also sensitive to damage," Michael Sixt states.



New gene potentially involved in metastasis identified

Cancers that display a specific combination of sugars, called T-antigen, are more likely to spread through the body and kill a patient. However, what regulates the appearance of T-antigen in cancer cells, the set of proteins modified with T-antigen, and the roles the T-antigen and the modified proteins play during metastasis, is not yet understood. A new study by Professor Daria Siekhaus and her research group at IST Austria, including first authors Katarína Valošková and Julia Biebl, identified a new gene in the fruit fly *Drosophila* that is required for regulating the addition of T-antigen onto a subset of proteins in immune cells. As the gene mutation causes immune cells to get stuck in the fly's head, the team called the new gene "Minerva", after the Roman goddess of wisdom who burst from her father Jupiter's head. The study published in eLife is a first step towards understanding new ways in which sugar modifications may be involved in metastasis.

Cancer cells metastasize by leaving their initial tumor site and squeezing between other cells to enter blood vessels, which they use as highways to zoom through the body. The metastasizing cells again squeeze between other cells to leave the blood vessels and enter tissues to form metastases. T-antigen, a combination of specific sugars, is detected on proteins on metastasizing human cancer cells, but is not normally found in most adult tissues. As immune cells in the fly, called macrophages, also carry T-antigens and squeeze through other cells to enter tissues, Daria Siekhaus and her group decided to use the fly and its immune cells as a model to study how the appearance of T-antigen on proteins is regulated and which proteins are affected by this. "The fruit fly is the best place to identify new pathways, as it is fast to do complex genetic experiments in the fly. Here again, we used the fly as an initial discovery engine for a problem that is also pertinent to us humans," Siekhaus explains.

ProfTalk

Sylvia Cremer, Evolutionary Biologist

What was your original field of study? I studied Biology with a focus on Zoology.

Why did you become a scientist? I became a scientist because I was interested in constant problem-solving.

What do you like about basic research? What I like most about basic research is that you can define your own questions and that these questions evolve over time.

What is your main area of research? My main study area is evolutionary ecology. We try to understand how different species solve problems based on their ecology and evolutionary past. My particular study area are the social insects and how they collectively defend their colony against diseases.

Which scientific result are you particularly proud of? During my PhD I studied conflict and cooperation in ant societies, and as a postdoc I worked on pathogens of social insects. When I then spent several months as a Junior Fellow at the Institute of Advanced Sciences in Berlin, I got the feeling that those two fields should be brought together in a more conceptual approach. So we tried to develop a conceptual framework for the study of collective disease defenses in social insects and wrote a review that became an important step in my career, also providing the name of social immunity to this field of research.

In empirical work, my first independent project and long-term grant was on social vaccination. We described the phenomenon that ants that take care of their diseased colony members contract a little bit of the pathogen themselves. These acquired low level infections do not cause diseases but an immune stimulation protecting the ants against infections with the same pathogen in their later lives. In other words, helping other colony members can improve their own physiological immune system.

Why did you join IST Austria? I joined IST Austria as one of the first experimental groups in 2010. In fact, I was already hired in 2009. Back then, during my interview, the first lab building was only a construction site that I visited with a helmet. I came here after I had finished my habilitation at the University of Regensburg. Although I had a long-term grant, my position would be running out two or three years later. So I was really looking for a place with a perspective, a place where I could stay if I proved successful. Therefore, I was quite attracted by the tenure-track system of IST Austria.

What is special about IST Austria? The special spirit of IST Austria is that it allows one to easily develop new ideas by conceptually interacting with colleagues that are from different research fields. In addition, IST Austria facilitates the establishment of new research methods because its shared facilities provide the equipment that is needed and the staff scientists support the research groups with their expertise to make the transition to a new method very easy.

Watch the entire ProfTalk interview on our YouTube channel!

SSU spotlight

Investing in mass spectrometry

Mass Spectrometry (MS) is an analytical technique which can measure the mass-to-charge ratio of ionized molecules, such as peptide fragments of proteins. In proteomics, MS is used to identify and quantify proteins in cells and tissues, as well as to analyze protein-protein interactions and protein modifications. In most cases, intact protein would be too complex to analyze, so they are first digested into shorter peptides. During MS analysis, a signature fragmentation spectrum is acquired for each peptide. As proteins are the main drivers of most processes in the cell, MS has become a very powerful tool that enables researchers to address exciting new questions in the protein world that would otherwise not be accessible.

A growing need for protein MS on campus became apparent as early as 2017. A survey among life sciences faculty showed that many research groups were already pursuing active collaborations with MS labs at other institutions or were planning to do so in the future. The lack of MS expertise at IST Austria was clearly marked as a restrictive factor for research. That was why a concept for the implementation of an MS service at IST Austria was developed and technical specifications of the required equipment were defined.

After careful evaluation of the researchers' needs, a Q-Exactive HF instrument was purchased and installed in April 2019. Its high field Orbitrap analyzer allows high-resolution mass measurements without compromising speed. Due to its high versatility and robustness, the instrument can reliably cover the vast majority of proteomics workflows.

MS Service is now being built up in Lab Building East as part of the Life Science Facility and will serve structural biologists, cell/developmental biologists, and neuroscientists alike. As of May 2019, the whole infrastructure is operational, and the first samples have been successfully analyzed.

"Proteomics is a fascinating but challenging field of investigation. As the main active agents in our bodies, proteins are much more interesting than DNA and RNA: they control reactions, create structures, they are both building elements and complex nano-machines. While DNA and RNA can be directly sequenced, this is not possible for proteins. Instead, in MS-based proteomics, we actually perform 'peptidomics' from which we indirectly infer proteomics-level information. In addition, peptides identification is not a straight-forward process and must be carefully controlled using statistical methods. Despite the complexity of the task, no other technique can capture the complexity and multi-dimensionality of the mysterious world of proteins," says Armel Nicolas, responsible for MS Service at IST Austria.

The Life Science Facility is one of eight Scientific Service Units currently established at IST Austria. Its excellently trained staff support experimental biologists in their research work. Its media and cleaning kitchen, fish and plant facility supply experimental resources at a consistently high level so the scientists can focus on their scientific questions as much as possible. For information visit our website.

IST Lecture by Paul Nurse on June 5

On June 5, Paul Nurse will give an IST Lecture on "Science as revolution". Nurse is Director of the Francis Crick Institute in London, and has served as President of the Royal Society, Chief Executive of Cancer Research UK and President of Rockefeller University. He shared the 2001 Nobel Prize in Physiology or Medicine and has received the Albert Lasker Award and the Royal Society's Royal and Copley Medals. In his talk, he will argue that science has brought about revolutionary changes in our understanding of ourselves and the natural world. Scientific knowledge has triggered revolutions in the ways that we live and in the technologies that support society. A case can be made that science is the most revolutionary activity of humankind. For information and registration visit our website.

ÖAW-IST Lecture by Bernhard Schölkopf on June 6

On June 6, Bernhard Schölkopf will deliver an ÖAW-IST Lecture on "Can Europe catch up in artificial intelligence?" Although today's machines can perform certain human tasks with remarkable accuracy, current technologies still lack versatility and only work within limited domains. These limitations are related to how machine learning, the technology powering AI, is performed. But with the constant stream of talented young scientists flocking into machine learning, significant developments are to be expected. In his talk, Schölkopf will discuss how Europe can partake in these developments by playing an active role in public AI research. Schölkopf researched at AT&T Bell Labs, at GMD FIRST, Berlin, and at Microsoft Research Cambridge, UK, before becoming Director of the Max Planck Institute for Intelligent Systems in 2001. For information and registration visit our website.

COLLOQUIUM SPEAKERS

PAST SPEAKERS: Michelle Simmons, University of New South Wales (Feb 1) | Charles Nunn, Duke University (Mar 11) | Paul Steinhardt, Princeton University (Mar 18) | Andrew Mackenzie, Max Planck Institute for Chemical Physics of Solids (Apr 8) | Roger Heath-Brown, Oxford University (Apr 29)

FUTURE SPEAKERS: Magdalena Götz, Ludwig Maximilian University of Munich (May 20) | Josh Sanes, Harvard University (May 27) | Gordon Wetzstein, Stanford University (Jun 24)

SELECTED RECENT PUBLICATIONS

Barton NH, Hermisson J, Nordborg M. 2019. Why structure matters. eLife. 8, e45380.

Chatterjee K, Goharshady AK, Pourdamghani A. Probabilistic smart contracts: Secure randomness on the blockchain. IEEE International Conference on Blockchain and Cryptocurrency.

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Fulek R, Pach J. 2019. Thrackles: An improved upper bound. Discrete Applied Mathematics. 259(4), 266–231.

Gerencser M. 2019. Boundary regularity of stochastic PDEs. Annals of Probability. 47(2), 804–834.

Goremykina A, Vasseur R, Serbyn M. 2019. Analytically Solvable Renormalization Group for the Many-Body Localization Transition. Physical Review Letters. 122(4).

Goudarzi M, Boquet-Pujadas A, Olivo-Marin JC, Raz E. 2019. Fluid dynamics during bleb formation in migrating cells in vivo. PLOS ONE. 14(2), e0212699.

Kavcic B, Sakashita A, Noguchi H, Ziherl P. 2019. Limiting shapes of confined lipid vesicles. Soft Matter. 15(4), 602–614.

Kazda A, Kolmogorov V, Rolinek M. 2019. Even delta-matroids and the complexity of planar boolean CSPs. ACM Transactions on Algorithms. 15(2).

Moser T, Seiringer R. 2019. Energy contribution of a point-interacting impurity in a Fermi gas. Annales Henri Poincare. 20(4), 1325–1365.

Nikolic N. 2019. Autoregulation of bacterial gene expression: lessons from the MazEF toxin–antitoxin system. Current Genetics. 65(1), 133–138.

Petridou N, Grigolon S, Salbreux G, Hannezo E, Heisenberg C-PJ. 2019. Fluidization-mediated tissue spreading by mitotic cell rounding and non-canonical Wnt signalling. Nature Cell Biology. 21, 169–178.

Sadel C, Xu D. 2019. Singular analytic linear cocycles with negative infinite Lyapunov exponents. Ergodic Theory and Dynamical Systems. 39(4), 1082–1098.

Truckenbrodt SM, Sommer CM, Rizzoli SO, Danzl JG. 2019. A practical guide to optimization in expansion microscopy. Nature Protocols 14, 832–863.

A full list of publications from IST Austria can be found in the IST Austria Research Explorer.

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