NEWSLETTER 40th edition | Spring 2022

Institute of Science and Technology Austria

Foreword

Dear reader,

Having served the Institute of Science and Technology Austria (ISTA) as president for over a decade since its inauguration in 2009, I am pleased to announce that Martin Hetzer will become the new president of our Institute.

Martin Hetzer was born in Austria and moved to La Jolla, California in 2004, where he established his research group at the renowned Salk Institute for Biological Studies and where he currently holds the position of Senior Vice President. After almost 20 years in the US, he will return to Austria and start as Professor in the life sciences and as the second President of ISTA on January 1, 2023.

Following the public advertisement and nominations, the search committee consisting of distinguished international scientists and top managers from industry appraised the profiles of 141 individuals in an elaborate screening process. Martin Hetzer was able to convince the search committee both in terms of his extensive scientific as well as leadership expertise. The focus of his research is on organismal aging with special emphasis on the heart and central nervous system. His lab has made several important contributions in cancer research and cell differentiation.

I am confident that Martin's broad vision for the future of ISTA, his proven track record in leadership matters, and his scientific background will enable him to master the challenges and seize the opportunities awaiting ISTA in the future.

Since its founding, ISTA has quickly reached worldwide visibility expanding the frontiers of science. I am enormously grateful to have had the opportunity to help shape the development of this unique institute. I look forward to devoting more time in the future to my research in computer science as Professor at ISTA. With the support of the entire campus community, I am certain that Martin will continue the Institute's successful path. I wish him all the best in this endeavor.

Thomas A. Henzinger | President, ISTA

ERC Grant for Lora Sweeney

Lora Sweeney and her team received a grant of 1.5 million euros from the European Research Council (ERC) for the research project "swim2limb". The goal is to gain deeper insights into the functioning of the spinal cord and the entire nervous system. In the future, the scientists hope to be able to use the gained knowledge to replace damaged or diseased cells in the human spinal cord. They also want to shed a new light on the evolutionary history of the brain and the nervous system.

The researchers want to find out which factors determine whether an animal can travel using only simple movements – for example, swimming –or a more complex movement process like walking. They will use the CRISPR/Cas9-method to completely remove one cell type and to see how this affects locomotor behavior. "I feel ecstatic and honored to be one of the recipients of the grant," says Sweeney, "when I first found out about it, I jumped up and down. For a young scientist like me, this is a huge opportunity that gives me the freedom to be more daring and to try new things. I'm very thankful."

Find out more in the press release.

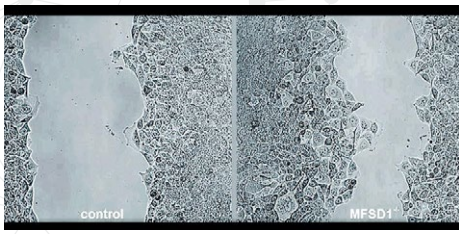
Funding the Research of Tomorrow

Research funding lays the foundations for a strong scientific community. The Austrian Science Fund (FWF) recently awarded grants totalling almost 15 million euros to four multidisciplinary research projects. Nine research groups at the Institute of Science and Technology Austria (ISTA) take part in these projects to bridge disciplines and to answer new scientific questions.

One of the projects brings together exotic forms of correlated quantum matter and quantum devices. This research could help develop novel machines and possible applications for quantum computers. Another one aims to create the technological foundations for security and privacy by design for IT infrastructure as required by the EU's General Data Protection Regulation. The third one will study how cell division for sexual reproduction in organisms can change or be lost altogether during evolution. The fourth project endeavors to optimize electrical machines by using novel simulation techniques.

Find out more in the press release.

Research Highlights

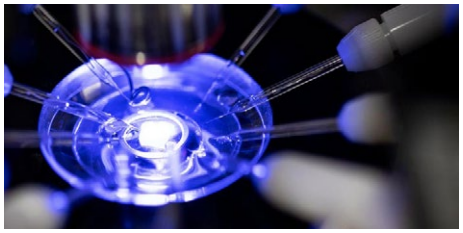


Suppressing the Spread of Tumors

When tumors spread, cancer cells migrate to other parts of the body through the blood or lymphatic vessels. The Siekhaus group, together with collaborators from the University of Zurich, have now found a new protein that prevents cancer cells from doing so by making them stick more tightly to their surroundings. Their findings, published in the journal Frontiers in Oncology, could help doctors determine the aggressiveness of a tumor and fine-tune therapy.

Why some patients develop metastases and others do not is largely unclear. Researchers around Daria Siekhaus are now contributing to a better understanding of the process in certain types of cancer. They took a close look at the role of a protein called MFSD1 – the mammalian relative of a protein they had previously identified as affecting cell migration in fruit flies. Therefore, first author Marko Roblek created mouse cancer cells lacking the protein. Without the protein, cells traveled much faster, suggesting that MFSD1 prevents the cells from moving. "In the absence of MFSD1, there was a strong increase in metastasis," Daria Siekhaus summarizes the results. The protein affects specific receptors located at the cell surface called integrins, which ensures the cells stick to each other and the extracellular matrix, a dense network surrounding the cells in our body. In a constant circle, the cell produces these receptors, transports them to the cell surface, and back inside the cell. If a tumor cell lacks MFSD1, they fail to recycle a certain type of integrin, resulting in cells that can move more freely. Furthermore, the team was able to show that without MFSD1 cancer cells are more resistant to nutrient starvation and mechanical stress, which helps them migrate through the body.

In the future, the team wants to focus in detail on how the protein functions on a molecular level and is curious to learn if artificially raising the amount of MFSD1 could help suppress the spread of certain tumors.

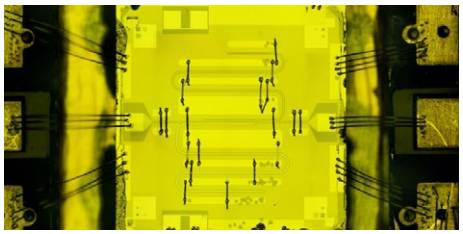


Spot the Difference

Our brains can distinguish highly similar patterns, thanks to a process called pattern separation. How exactly our brains separate patterns is, however, not fully understood yet. Using a full-scale computer model of the dentate gyrus, a brain region involved in pattern separation, Peter Jonas and his team found that inhibitory neurons activated by one pattern suppress all their neighboring neurons, thereby switching off "competing" similar patterns. The results have been published in Nature Computational Science.

In previous research, the Jonas group measured crucial parameters of synapses, the connecting points of neurons, and connectivity rules, which are required for understanding information processing in the hippocampal network in mice and rats. In their new study by first author Jose Guzman, the group used these real-live parameters to build an accurate model of the network – a challenge, as usually, models of brain circuits are built with just 10 to 1,000 neurons. The dentate gyrus of rats, however, contains 500,000 excitatory neurons, called granule cells. "In scaled-down models, we cannot plug in the measured synaptic parameters of the neuronal circuit. But as we wanted to mimic what happens in the brain and use synaptic measurements we obtained previously, we implemented a network in its full size, with 500,000 granule cells."

Using this computer model, Jonas tested different hypotheses of how pattern separation works. "With this model we cannot just copy biology, but systematically change parameters and disentangle factors. This allows us to understand computations in the brain, and how biological factors support or limit computation." The team discovered that inhibition – active neurons stopping other neurons from firing – plays an important role in pattern separation. "This modelling data changes the historical view from code expansion to a mechanism based on inhibition." The network model shows that focal inhibition can better separate patterns than global inhibition, in which the entire network's activity is dampened down.



Characterizing Super-Semi Sandwiches for Quantum Computing

Semiconductors are the foundation of modern technology while superconductors with their zero electrical resistance could become the basis for future technologies, including quantum computers. So-called "hybrid structures" – carefully crafted sandwiches made from superconductors and semiconductors – may lead to new quantum effects. However, convincing observations have remained elusive. Researchers at ISTA with NYU collaborators found a way to probe such "super-semi sandwiches" and to reveal what is going on.

"There is an international race to identify the best platform for controlling and processing quantum information for quantum computers, where superconductors play a prominent role," says Duc Phan, PhD student and first author of the paper published in *Physical Review Letters*. "However, before we can use them, we must understand the fundamental physics behind them."

The researchers developed a technique to probe the quantum interactions in superconductor-semiconductor sandwiches paving the way for new applications like topological quantum bits based on so-called Majorana zero modes. This first experimental result of the Higginbotham group since its establishment at ISTA lays the groundwork to study superconductor-semiconductor hybrid structures at a new level of detail. "The parameters we can infer from this could provide much-needed guidance to construct topological quantum bits based on Majorana zero modes," says Jorden, one of the co-authors. "ISTA is very well placed in this developing field because here experimental expertise, theoretical understanding, as well as excellent infrastructure provided by the state-of-the-art clean room come together."

Phan and his colleagues are excited about what insights they will gain with their novel probing technique and what future applications may become possible once the fundamental physics of this exotic sandwich has been understood.

Logo change

IST Austria becomes ISTA

An institute like ours is constantly evolving: every year new scientists arrive, new insights are gained, and new technologies are developed.

After twelve years of the Institute's history, it has become time to refresh our look," says Thomas Henzinger, President of ISTA.

The new logo conveys a modern, fresh, less formal look of a young and dynamic institute, while upholding a clean and reputable image at the same time.

ISTA Institute of Science and Technology Austria

In 2022, IST Austria transitioned to the fresh and modern look of ISTA.

Different shades of green express the diversity at ISTA. The four elements can be interpreted in many different ways, such as books on a shelf storing knowledge, a bar graph indicating change, a sequence of dominoes triggered by an action, or consecutive snapshots of an idea taking off.

With the introduction of the new abbreviation "ISTA" - read as one word - we ensure that our name can be pronounced well and consistently in many different languages.

Soon ISTA's new colors will be seen all over campus, including our Raiffeisen Lecture Hall.

With the new logo, the Institute's appearance will be revitalized.

More information on ISTA at ista.ac.at.

SSU spotlight

Expansion of the Fish Facility

The zebrafish has become a well-established vertebrate model system that is particularly useful for the study of developmental processes. The unique features that make it stand out amongst other model organisms are that fertilization and development of embryos occur externally, that a single female can produce large numbers of eggs in one batch (more than 100), and that embryos are transparent which allows their visualization during development.

In 2010, ISTA built its zebrafish breeding facility as one of the first scientific services on campus. The facility has developed very well and enabled us to establish a flourishing zebrafish colony on campus that supports exciting scientific projects. Now, after more than ten years, the system reached the end of its lifetime and needs to be replaced.

When the first facility was built, the focus was on maximizing space efficiency to accommodate a large number of aquaria in a small footprint. Today, it contains 806 ten liter aquaria and 640 three liter aquaria leading to an impressive maximum capacity of about 60,000 animals. During the past years, it became apparent, however, that this theoretical maximum was never reached, mostly because the capacity of the big tanks was not sufficiently utilized. The facility holds roughly 30,000 animals at any given time. Additionally, it became clear that the space efficiency comes at a cost, namely time-consuming cleaning routines and the lack of proper decontamination possibilities.

For the new system, we thus decided to focus even more on improving hygiene standards and processes. We have chosen a system exclusively based on smaller-sized tanks that can be removed from the system and cleaned in a dedicated tank washer with a decontamination function. The tanks have a self-cleaning function that automatically removes contaminants from the tank floor and inhibits algae growth. An additional highlight is that all relevant parameters (e.g. water conditions, pump pressure, etc.) can be accessed remotely giving the facility staff additional control. The new system contains 1,344 3.5 liter tanks providing space for about 28,000 animals.

In a fruitful collaboration with our Construction division, the space was reconstructed to fit the new tank configuration. During a period of about six months, the entire floor, the ventilation system, and the lights were remodeled while normal operations continued in the remaining facility.

Starting soon, the animals will be transferred to the new system with the utmost care. Only healthy offspring of the current livestock will be transferred in order to avoid carryover of pathogens by adult animals from the old system. Therefore, it will take a least one year until all fish lines are relocated. Once the move is completed, the old system will be disassembled and as well replaced by new tanks. We look forward to a completely new and expanded fish facility in 2024.

More information on the Fish Facility can be found on the Lab Support Facility webpage.

New R&D lab at IST Park

Quantum Power Transformation has patented technology to drive next-generation GaN transistors with TeraHertz precision timing and in combination with applying IP from radar, radiofrequency systems, plasma control, and EDM (Electric Discharge Machining) technologies. QPT is pleased to have their R&D lab at IST Park with excellent infrastructure and international academic reputation.

The R&D lab develops the next generation of high performance, multi-channel, intelligent, programable power systems, which can be applied in many diverse applications, such as plasma systems, ECM, EDM, metal 3DP, and next-generation low field rapid MRI scanners.

In the longer term, they will develop custom ASICS (Application Specific Integrated Circuits) and turnkey GaN power modules that can be used in volume products such as motor drives (VFD, Servo, HF spindle, etc.) and many other power conversion applications.

QPT

Science Education Day 2022

On March 30, the Science Education Day themed "A world full of data" took place on campus.

In keynotes and workshops, participants addressed the challenges and opportunities of a "world full of data," gained insights from experts, and received input for their own teaching of data literacy to students.

For more information about the Science Education Day, please visit the event's webpage.

COLLOQUIUM SPEAKERS

PAST SPEAKERS: Henry Adams, Colorado State University (Jan 24) | Yang Shao-Horn, Massachusetts Institute of Technology (Jan 31) | Florian Schur, ISTA (Feb 21) | Jeanne Stachowiak, University of Texas (Mar 7) | Maya Cakmak, University of Washington (Mar 14) | Sarah Cohen, UNC at Chapel Hill (Mar 21) | Romana Schirhagl, University of Groningen (Mar 28)

FUTURE SPEAKERS: Isil Dillig, University of Texas (Apr 4) | Olgica Milenkovic, University of Illinois at Urbana-Champaign (Apr 25) | Megan Carey, Champalimaud Center for the Unknown in Lisbon (May 2) | Carla Shatz, Stanford University (May 9) | Zoltan Haiman, Columbia University (May 16)

SELECTED RECENT PUBLICATIONS

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Hosten, O. (2022). Constraints on probing quantum coherence to infer gravitational entanglement. Physical Review Research. American Physical Society.https://doi.org/10.1103/PhysRevResearch.4.013023

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Mysliwy, K., &; Seiringer, R. (2022). Polaron models with regular interactions at strong coupling. Journal of Statistical Physics. Springer Nature.https://doi.org/10.1007/s10955-021-02851-w

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

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