NEWSLETTER 38th edition | Fall 2021

IST AUSTRIA
Institute of Science and Technology

Foreword

A point to remember in the young history of IST Austria: On September 29, the Council of Ministers approved a new 15a-agreement between the Federal Government of Austria and the Province of Lower Austria which provides future financing for IST Austria. Specifically, IST Austria will receive 3.3 billion EUR in public funding from 2027 to 2036, provided we will raise an additional 400 million EUR in third-party funds. This means that the Institute will be able to expand to about 150 research groups by 2036. The growth will be continuous: We will continue to add five to six new research groups a year for the next 15 years, just as we have done in the past 12 years. We will be able to strengthen all existing fields of science, including earth science, possibly enter new fields, such as astro science, and also add more interdisciplinary and more technology-oriented scientists. The Austrian and Lower Austrian parliaments are expected to pass the 15a-agreement in the next months. This will finally conclude a process that started three years ago and included a strategic development plan as well as an institute evaluation.

The Austrian public has put enormous trust in us. This trust is based on our past achievements, and every IST Austria employee has contributed to these achievements in essential ways. Let us continue on our successful path and make IST Austria the globally known brand for cutting-edge science we all want it to be. With all the talent we have and are going to have on campus, I know that we can not only fulfill the expectations but exceed them.

Thank you for supporting IST Austria!

Thomas A. Henzinger | President, IST Austria

Gardening for Science

Some fields of biology require studying living subjects. At IST Austria, scientists use *Arabidopsis thaliana*, also called thale cress, to experiment on. Taking care of thousands of these plants is a complex undertaking, but plant facility technician Dorota Jaworska alongside scientists from the Benková and the Friml group are up to the task.

While not being an eye-catching plant, *Arabidopsis thaliana* plays a crucial role in plant biology. First selected for this use at the beginning of the twentieth century by the German scientist Friedrich Laibach, it quite literally grew to become the standard for genetic experiments on plants. It can be cultivated quickly, matures in just six weeks, and produces a high yield of tiny seeds. The seeds are then stored in a seed bank to be kept for future use.

Each lab working with *Arabidopsis thaliana* has its own genetic lines – a family tree containing plants with specific features like size, look, or resilience against temperature changes and droughts.

Three IST Austria Professors join Academia Europaea

The Academia Europaea is a pan-European, non-governmental scientific society. Its members are researchers from various scientific disciplines who wish to promote education and research worldwide. Now, IST Austria Professors Mario de Bono, Vadim Kaloshin, and Robert Seiringer enter this prestigious society. “It is quite an honor to be selected to join this prestigious society, and of course, it always feels good if a wider scientific community recognizes one’s achievements,” says Robert Seiringer. They join over 4,000 experts, including over 50 Nobel Prize winners and seven colleagues from IST Austria.

Mario de Bono dissects the evolutionarily conserved building blocks that govern the properties of neurons and circuits in worms. Vadim Kaloshin explores the rigidity of sound. He investigates how the shape and sound of a drum connects. Robert Seiringer develops new mathematical tools for the analysis of many-particle systems in quantum mechanics.

IST Austria congratulates 45 new PhD graduates

The academic years 2019-2020 and 2020-2021 were anything but usual. The global pandemic had an immense impact on the IST Austria Graduate School, and yet, even under these challenging circumstances, IST Austria is proud to announce that 45 students graduated with a PhD. Coming from 18 different countries, they represent all scientific fields on campus. After years of dedication, learning, and independent research, these new alumni will pursue careers in academia and the industry.

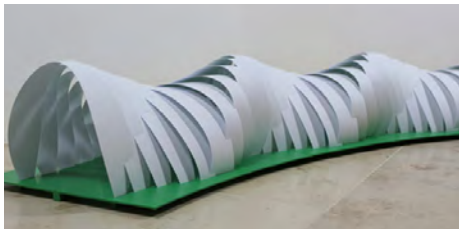
IST Austria alumni are found everywhere in the world, and their careers include professor positions or essential roles in the industry. Since its founding in 2009, IST Austria now has a total of 118 graduates.

Research Highlights

The Twinkle and the Brain

In defining periods of development, the brain reorganizes connections between its neurons more freely than in its adult form. Researchers from the Siegert group have now discovered two methods to reopen such plasticity: repeated ketamine anesthesia and non-invasive 60 hertz light flickering. Their findings, which have the potential to become a therapeutic tool applicable to humans, were published in the journal *Cell Reports*.

It all began four years ago when researchers at IST Austria found that microglial cells in mice become very reactive after they had anesthetized animals with the drug ketamine. Microglia are typically seen as the brain's immune cells. Recent studies however have shown that they also interact with neurons. Reactive microglia have the ability to eat synapses and even entire neurons which is often seen in the late phases of Alzheimer's disease. "The strong response of the microglia upon ketamine anesthesia surprised us," explains leading author Alessandro Venturino. "But we did not see any synapses or dead neurons vanishing. So, we were puzzled, what the microglia were actually eating." It turned out to be the perineuronal net, a structure that protects and stabilizes the connections between neurons. Neurons communicate by sending electric impulses to each other. These are coordinated to create waves of signals – so-called brainwaves – which can be influenced by external sensory information, for example, light entering into the eye. "It had been previously shown that light flickering 40 times a second – at 40 hertz – can promote microglia to remove plaques in Alzheimer disease. But it did not remove the perineuronal net," Venturino explains. When the scientists then put mice in boxes with light flickering 60 times a second, however, it had a similar effect as the ketamine treatments. "This fine-tuning between distinct brainwaves and the microglia action is the most fascinating and might be a new way of thinking about brainwaves."



Virtual Yarn and Elastic Beams

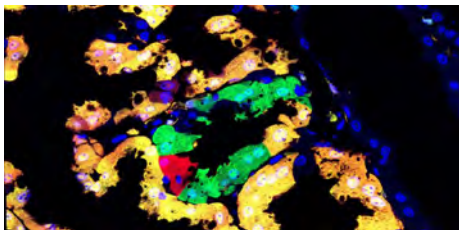
Computer simulation is often a compromise. The more details it includes, the longer computation usually takes, or more expensive hardware is required. Chris Wojtan, Bernd Bickel, and their research groups challenge this conundrum. They came up with clever and powerful algorithms that can animate knitted cloths with intriguing detail and enable the design of curved components for architecture, while in both cases maintaining low computing costs. The scientists presented their results at the renowned SIGGRAPH conference.

Stretching the Power of Knitted Yarn Animation

Calculating the behavior of each individual thread is computationally very costly. A new method can now calculate how a tiny patch of the repeating yarn pattern reacts to different deformations. This is like collecting a library of possible local movements and positions of the individual threads for a certain knitting pattern. The algorithm tiles these patches onto the grid of the underlying mesh-based simulation. When a twisted sleeve is animated, each deformed triangle serves as an indicator, telling the computer which yarn deformation from the precomputed library it should put there. The method can be parallelized and by this allows for real-time animation, even for millions of yarn stitches.

Designing with Elastic Elements

Bending of slender beams allows for the realization of spectacular structures in architecture, furniture, and product design. With a new algorithm, doctoral student Christian Hafner found an efficient and witty way to digitally create designs which can then be physically realized by bending flat beams into curved shapes. Manufacturing beams in a flat state first minimizes material waste and makes the most out of naturally elastic materials such as timber. The researchers also show how to optimize the beam shapes for simple manufacturing and how to balance out the effect of gravity without slowing down the algorithm.



Boost for mouse genetic analysis

While in principle, the genome in all cells of an organism is the same, mutations can and do arise in individual cells. These mutations make a cell different from its neighbors, and the organism forms a "genetic mosaic". Simon Hippenmeyer with collaborators have made almost all genes in the mouse genome accessible to single-cell genetic mosaic analysis. Their resource, a genome-wide library of Mosaic Analysis with Double Markers (MADM) mice for single-cell genetic mosaic analysis, was published in the journal *Cell Reports*.

In the experimental genetic mosaic approach, MADM genes are mutated in individual cells while, at the same time, being labeled in fluorescent colors. By altering a gene in a single cell, while keeping the remaining cells "normal", scientists can follow what happens to the mutated single cell and gain insight into the role and function of the mutated gene. This approach is especially valuable for essential genes: Mutating an essential gene in all cells of an organism would affect the organism's health and viability. But when the gene is mutated in just a few select cells, the organism itself is unaffected, while scientists can follow what happens to the sparse mutated cells – their morphology, development, and function – at the individual cell level.

Up until now, only about 25 percent of mouse genes could be mutated and followed using the MADM technique, as this technology was limited to three of the mice chromosomes. The Hippenmeyer group has dramatically expanded this resource, successfully placing the "MADM marking cassette" required for the MADM technique on all mouse chromosomes (except the sex chromosomes). Now, more than 96% of genes can be altered and traced on the single-cell level. "We can now easily manipulate almost every mouse gene, and subject every gene to high-resolution, phenotypic genetic mosaic analysis," Hippenmeyer explains.

IST4Kids

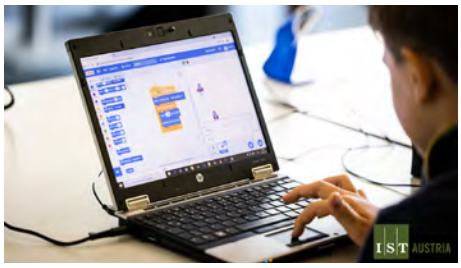
Discovering the world of science!

Every year, IST Austria hosts different science camps in August. At these camps, children can discover the world of science, get an idea of what it is like to be a scientist, and live out their curiosity. This year IST Austria welcomed more than 80 participants on campus.

The **Sommercampus Kids** is IST Austria's annual science camp for elementary school children. In five different groups, children meet scientists and engage in hands-on activities to explore Physics, Biology, Robotics, Art, and History. Their weeklong journey culminates in a graduation ceremony and an exhibition of their own creations and findings. Sommercampus Kids is a collaboration between IST Austria, Museum Gugging, Klosterneuburg Abbey and the University College of Teacher Education Lower Austria.

In 2021, IST Austria established two new science camps for older children: Sommercampus Juniors and Fakebusters Bootcamp.

Sommercampus Juniors is aimed at middle school children. During the three-day camp, the children take on the role of scientists and conduct experiments in biology, chemistry and physics. They get the chance to meet IST Austria researchers and discover the laboratories on campus.



For the first time, IST Austria offered a camp dedicated to high-school students: the **Fakebuster's Bootcamp**.

The objective is that participants are able to experience science as a systematic way to understand the world, and to examine the difference between reliable scientific information and fake news. They engaged in experiments, role-play and took part in guided discussions with scientists from various disciplines.

The registration for next year's science camps will open in spring 2022 and will be announced in the next edition of Science Education News.

Further information on science education and events for children can be found on our science education webpage.

SSU spotlight

Image by Caroline Süzl

The new library

The new Sunstone Building contains a new, spacious library. Although it might seem counter-intuitive to build physical libraries in this digital age, our experience has shown that researchers appreciate them as a place to think and focus. This physical space will complement the library's virtual services.

TThe library has been designed in such a way that various working environments can be accommodated: The so-called **Idea Area** is intended as a breeding ground for new ideas, providing space for discussion. Here, silence is not mandatory. The **Work Area**, which consists of work tables and single booths, houses the collection of publications. It has a reading area and also offers a peaceful view from the windows. This is a quiet zone. Finally, the **Focus Area** provides library users with a space where they can concentrate and focus on their writing.

Image by Caroline Süzl

Therefore, it has been designed to be as quiet as possible. For example, the delineated work tables will reduce distractions from others. The new library's physical space is intended to complement the library's virtual services.

More information on the library and its services can be found on its webpage.

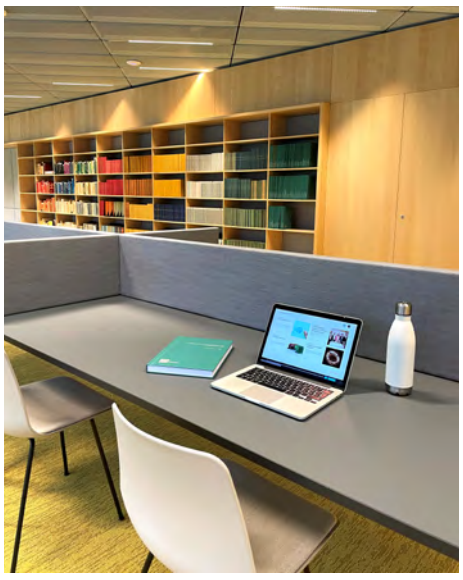


Image by Patrick Danowski

Recap: Open Campus 2021

On September 19, the annual Open Campus Day took place at IST Austria. On this day, the Institute opened its doors to the general public once more by organizing a big science party for the whole family.

Visitors got the opportunity to immerse themselves in scientific and basic research, by visiting interactive exhibitions, meeting scientists and going on guided lab tours!

Further information and details about the event can be found on the Open Campus webpage.

Sunstone Building – a meeting place for theory and experimentation

September 19 also marked the occasion for the opening of the Sunstone Building. This building is the ninth building on campus. The building has a floor area of over 10,000m2 and will host theoretical and experimental research groups. 120 researchers will work in 12 research groups.

The Sunstone Building is home to the new Library, the Graduate School and the new Nuclear Magnetic Resonance facility.

Details on the building's opening celebration can be found in the news story.

COLLOQUIUM SPEAKERS

PAST SPEAKERS: Irene Miguel-Aliaga, Imperial College London (Apr 26) | Katia Bertoldi, Harvard University (May 10) | Cristina Marchetti, University of California Santa Barbara (May 17) | Verena Winiwarter, BOKU (Jun 2) |Michele Devoret, Yale University (Jun 21) | Jeanne Stachowiak, University of Texas at Austin (Sep 6) | Jeanne Stachowiak, University of Texas at Austin (Sep 6) | Vidya Madhavan, University of Illinois Urbana-Champaign (Oct 11)

FUTURE SPEAKERS: Lillian Pierce, Duke University (Oct 18) Yang Dan, University of California, Berkeley (Nov 15) | Aviv Regev, Massachusetts Institute of Technology (Dec 16) | Lenka Zdeborova, EPFL (Jan 24)

SELECTED RECENT PUBLICATIONS

Pitrik, J., &; Virosztek, D. (2021). A divergence center interpretation of general symmetric Kubo-Ando means, and related weighted multivariate operator means. Linear Algebra and Its Applications. Elsevier. https://doi.org/10.1016/j.laa.2020.09.007

Li, H., von Wangenheim, D., Zhang, X., Tan, S., Darwish-Miranda, N., Naramoto, S.,https://doi.org/10.1111/nph.16887__Friml, J. (2021). Cellular requirements for PIN polar cargo clustering in Arabidopsis thaliana. New Phytologist. Wiley.https://doi.org/10.1111/nph.16887

Ke, M., Ma, Z., Wang, D., Sun, Y., Wen, C., Huang, D.,https://doi.org/10.1111/nph.16915__Chen, X. (2021). Salicylic acid regulates PIN2 auxin transporter hyper-clustering and root gravitropic growth via Remorin-dependent lipid nanodomain organization in Arabidopsis thaliana. New Phytologist. Wiley.https://doi.org/10.1111/nph.16915

Browning, T. D., &; Heath-Brown, R. (2021). The geometric sieve for quadrics. Forum Mathematicum. De Gruyter.https://doi.org/10.1515/forum-2020-0074

Bozelos, P., &; Vogels, T. P. (2021). Talking science, online. Nature Reviews Neuroscience. Springer Nature.https://doi.org/10.1038/s41583-020-00408-6

Brown, A., &; Romanov, A. (2021). Contravariant forms on Whittaker modules. Proceedings of the American Mathematical Society. American Mathematical Society.https://doi.org/10.1090/proc/15205

Zeiner, M., Schmid, U., &; Chatterjee, K. (2021). Optimal strategies for selecting coordinators. Discrete Applied Mathematics. Elsevier.https://doi.org/10.1016/j.dam.2020.10.022

Runkel, I., &; Szegedy, L. (2021). Area-dependent quantum field theory. Communications in Mathematical Physics. Springer Nature.https://doi.org/10.1007/s00220-020-03902-1

Ramirez Villegas, J. F., Besserve, M., Murayama, Y., Evrard, H. C., Oeltermann, A., &; Logothetis, N. K. (2021). Coupling of hippocampal theta and ripples with pontogeniculooccipital waves. Nature. Springer Nature.https://doi.org/10.1038/s41586-020-2914-4

Marquès-Bueno, M., Armengot, L., Noack, L., Bareille, J., Rodriguez Solovey, L., Platre, M.,https://doi.org/10.1016/j.cub.2020.10.011__Jaillais, Y. (2021). Auxin-regulated reversible inhibition of TMK1 signaling by MAK modulates the dynamics of root gravitropism. Current Biology. Elsevier.https://doi.org/10.1016/j.cub.2020.10.011

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

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