NEWSLETTER

31st edition | Winter 2019

IST AUSTRIA
Institute of Science and Technology

10 YEARS

Foreword

Over the long history of our planet, organisms have adapted to make their living in extraordinarily diverse ways—from bacteria that exploit almost any conceivable source of energy, to animals such as ourselves, whose brains can understand and manipulate the world around them. Yet, such diverse adaptations have evolved through the simple process of natural selection, which gradually accumulates favorable variation. My research aims to understand this evolutionary process, using the quantitative tools of population genetics.

My central focus has been on *hybrid zones*: narrow regions where distinct populations hybridize. These are striking phenomena, which occur in all sexual organisms: I have studied grasshoppers, butterflies, toads, and most recently, snapdragons. Yet, they illuminate general principles that can be applied more widely. Thus, my work has developed in unexpected ways, including the genetics of complex traits, the efficiency of evolutionary algorithms in computer science, and the design of programs to control mosquito-transmitted diseases, such as dengue. A wide range of methods is involved—fieldwork, genomics, mathematics, etc.—and so IST Austria has been an ideal setting for such interdisciplinary work.

When I joined IST in 2008, as the first professor, it was hard to imagine that the original building site would transform within ten years into such a thriving institute. Yet, many features remain from the early days: a: Yet, many features remain from the early days: a determination by the faculty to facilitate cross-disciplinary communication, sharing of space and core facilities, and a single cross-disciplinary Graduate School that brings together diverse students.

Nick Barton | Dean of the Graduate School and Professor, IST Austria

Opening Technology and Research Center IST Park

On September 30, the new technology and research center, IST Park, opened across the IST Austria campus, after one and a half years of construction. With an initial investment of 15 million euros, including ERDF (European Regional Development Fund) funding, the Lower Austria business agency ecoplus GmbH, together with IST Austria established a state-of-the-art center for Institute related research facilities, spin-offs, and technology-oriented companies.

The IST Park is primarily intended to offer companies from research-intensive areas, start-ups and spin-offs, who benefit from proximity to IST Austria, the best possible framework conditions. With IST Park, there are now a total of six technology and research centers in Lower Austria.

Watch the opening video here.

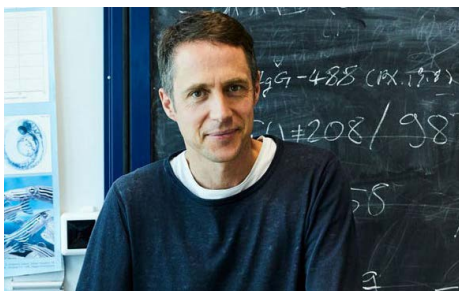
ecoplus EFRE
Europäische Union Investitionen in Wachstum & Beschäftigung. Österreich.

Applications Open: PhD program 2020

IST Austria is looking for highly qualified candidates to apply for next year's PhD program starting in September 2020. Our broad-minded scientists perform cutting-edge, curiosity-driven research. Students with a bachelor's or master's degree in the natural and mathematical sciences are encouraged to apply.

PhD students at IST Austria benefit from a fully-funded PhD program and get the chance to broaden their scientific experience in basic research within biology, computer science, data science, physics, mathematics and neuroscience. Interested students are invited to visit the campus on the annual Student Open Day on November 22, 2019, where they will have the chance to meet with professors and various research groups.

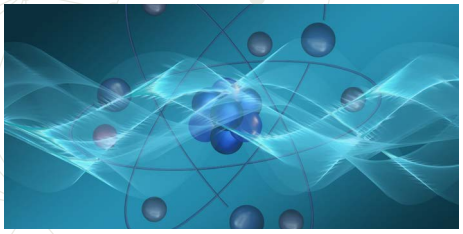
Further information, as well as the registration, can be found on the PhD website. The registration deadline for the PhD program is January 8, 2020.



Carus Medal awarded to IST Austria professor Carl-Philipp Heisenberg

The German Academy of Sciences, Leopoldina, awarded this year's Carus Medal to IST Austria developmental biologist Carl-Philipp Heisenberg for his outstanding research achievements. The medal recognizes important scientific discoveries or research achievements of young researchers in one of the scientific areas represented by Leopoldina.

Developmental biologist Professor Carl-Philipp Heisenberg studies the embryonic development of vertebrates. His research is characterized by its multidisciplinary approach at the interface of cell biology, developmental biology and biophysics. The fundamental work from Heisenberg's research group has significant potential to impact developments in medicine as immune and cancer cells have many similar properties to embryonic cells. Arriving at IST Austria in 2010, Carl-Philipp Heisenberg was among the first professors of IST Austria.



New form of magnetism found

Advances in science and technology over the past few decades have allowed physicists to study nature at an increasingly finer scale. As the study of natural systems shrinks further and further, new physical phenomena are being unveiled. Now, a multi-national research team including a postdoc from the research group of Mikhail Lemeshko has discovered a new form of magnetism within the interaction of two ultra-thin atomic layers. Their results were published in the journal *Physical Review Letters*.

At a microscopic level, magnetism is the result of the sum of the magnetic moments of the fundamental constituents of matter. A complete understanding of the familiar magnetic attraction and repulsion forces we see in everyday objects requires a microscopic description that takes into account quantum mechanics. In their study, first authors Giacomo Bighin, IST Austria, and Nicolò Defenu from the University of Heidelberg along with colleagues from Hungary and Italy describe the magnetism of a system consisting of a pair of two-dimensional layers of atoms, stacked on top of each other. The research team has shown that in such a system, a new form of magnetism can be present.

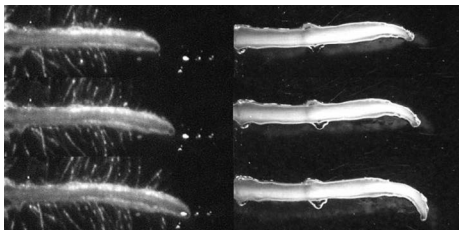
While the discovery is still theoretical, the researchers are already looking for experimental physicists to confirm their theory using real systems. One way to realize such a system would be to use ultra-cold atoms that can be arranged into lattices using laser light. As the study shows, the closer the two layers are to each other, the more important this new form of magnetism becomes. “As our electronic devices continue to shrink, it’s important to understand such effects”, says Bighin. Also, the theory developed by the researchers can be applied to other physical phenomena such as superconductivity and superfluidity.

High-end microscopy reveals structure and function of crucial metabolic enzyme

The enzyme *transhydrogenase* plays a central role in regulating metabolic processes in animals and humans alike. Malfunction can lead to serious disorders. Professor Leonid Sazanov and his research group have now visualized and analyzed the enzyme’s atomic structure with the support of one of the institute’s newly installed high-end cryo-electron microscopes. The data presented in the journal *Nature* are relevant for the development of currently unavailable therapeutic options.

Within each cell, there are tiny powerhouses called mitochondria which continuously break down molecules derived from food to generate energy as well as to produce new molecules that serve as building blocks of cells. Balancing these two opposing processes is accomplished by an enzyme called proton-translocating transhydrogenase, or NNT (nicotinamide nucleotide transhydrogenase). NNT sits in the mitochondria’s membrane and uses the electrochemical proton gradient generated by cellular respiration to provide the mitochondria with just the right amount of the co-enzyme NADPH, a vital metabolic precursor. The proper functioning of NNT is crucial for metabolic regulation in all animals, including humans. However, the details of how NNT accomplishes the coordinated transfer of protons across the membrane and synthesis of NADPH have remained obscure due to the lack of knowledge about the enzyme’s atomic structure.

PhD student Domen Kampjut and his supervisor and group leader Leonid Sazanov have now, for the first time, visualized the molecule of mammalian NNT at a scale that allowed them to identify the structural principles of the enzyme’s channel gating—thus to gain a deeper understanding of its functioning (and malfunctioning).



When plant roots learned to follow gravity

Highly developed seed plants evolved deep root systems that are able to sense Earth’s gravity. The ‘how and when’ of this evolutionary step has, until now, remained unknown. Plant biologists from the group of Jiří Friml have identified crucial components and processes which only developed in seed plants around 350 million years ago to enable fast and efficient gravity-driven root growth. The results were published in the journal *Nature Communications*.

Yuzhou Zhang, a postdoc in the Friml group, and his team have gained a broader view of how and when root gravitropism evolved. Through analyzing the distinct phases of gravitropism—gravity perception, the transmission of the gravitropic signal, and ultimately the growth response itself—the researchers found two crucial components, which evolved hand in hand. The first turned out to be an anatomical feature: Plant organelles called amyloplasts—densely filled with starch granules—sediment in response to gravity and this way function as gravity sensors. After perception through the amyloplasts, the gravity signal is further transmitted from cell to cell by the growth hormone auxin.

With these two anatomical and functional components identified, the authors have gained valuable insights into the evolution of root gravitropism, which is one of the crucial adaptations of seed plants to land. But even practical implications of these findings are conceivable: “Now that we have started to understand what plants need to grow stable anchorage in order to reach nutrients and water in deep layers of the soil, we may eventually be able to figure out ways to improve the growth of crop and other plants in very arid areas,” says Zhang. He adds: “Nature is much smarter than we are; there is so much we can learn from plants that can eventually be of benefit to us.”

Celebrating 10 Years IST Austria: a review

2019 marked the ten-year anniversary of IST Austria. Since the opening of the campus back in 2009, the Institute has already passed many milestones—in research, recruitment, construction, grants, and fundraising. Reason enough for employees and guests to celebrated the anniversary with a week of festive events in June!

During the 10 Year celebration, Austrian President Alexander Van der Bellen congratulated the Institute stating: "an Austrian miracle happened". He further said: "It is great to have a place like IST Austria in Austria, where national and international big shots in science come together." Public lectures by Nobel Laureate Sir Paul Nurse and Bernhard Schölkopf rounded off the anniversary week.

IST Austria was established by law in 2006 by the Federal Government of Austria and the State Government of Lower Austria with its campus opening in 2009.

Not only during the last decade, but also during the anniversary year, IST Austria has reached noteable milestones. In June, "Nature Index 2019" ranked IST Austria No. 3 worldwide in their first normalized ranking concerning the quality of its research output. The Nature Index ranking confirms that IST Austria now successfully competes with the world's most famous research institutions. Apart from IST Austria, only two other European institutions (EPFL Lausanne and ETH Zurich) made it to the Top 25 in this ranking.

The launch of the BRIDGE network counts as another big achievement. The member institutes of the BRIDGE network pursue two missions: to perform cutting-edge research and to train the next generation of PhD graduates. This is represented by the name of the network: "**B**asic **R**esearch **I**nstitutions **D**elivering **G**raduate **E**ducation". BRIDGE members (Francis Crick Institute, OIST, Rockefeller University, Weizmann Institute of Science and IST Austria) combine the best of both worlds for top researchers: on the one hand, they offer freedom and availability of resources to fully concentrate on research and, on the other, a steady influx of brilliant young scientists. The network provides a basis for a fruitful exchange of best practice models between its members. The combined expertise in the management and administration of research institutes and graduate universities aims to benefit both science and society.

After one and a half years of construction, the technology and research center, IST Park, opened its doors in September. Other construction projects at the institute are also steadily moving forward with 'Lab Building 5' scheduled to open in 2020. Lab 5 will offer space to chemistry groups, the Institute's library and graduate school. Construction works for the Visitor Center will start next year.

While much has already been achieved, IST Austria still holds big visions for the future, and embarks on the next ten years dedicated to creating an institute of world-class science, facilities, and training.

Watch the video of the entire 10-year celebration on our YouTube channel!

The Growth of the Miba Machine Shop at IST Austria

Among the many accomplishments of IST Austria this year, the Miba Machine Shop grew not only by a building, but also acquired a new machine, or to be more specific: a water jet cutter.

The Miba Machine Shop is one of eight Scientific Service Units (SSU) currently established at IST Austria. Its team provides expertise in the development and production of mechanical and electronic equipment for specialized experiments as well as on-going technical support. Additionally, they take care of the maintenance, upkeep and emergency repair of scientific instruments and devices.

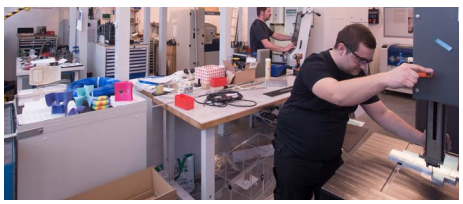
On November 14, the new building extension for the Miba Machine Shop was officially opened, providing more space for housing and the operation of equipment. The building directly connects with the old structure and offers an area for offices on the first floor. The downstairs area provides room for machines, storage and workspace as well as the new teaching lab, where PhD students can learn, practice, and create their own small parts for research projects.

The original building was first established in 2010 and was staffed by four team members. Since then, a growing demand for expertise has resulted in the team growing to ten staff members: three employees, one apprentice, two developers, and four people working in the electronics department (E-Shop). Today, staff members produce and provide specialized mechanical and electronic equipment for all experimentalists, including neuroscientists. They manufacture complete technical solutions for non-standard experiments and construct prototypes, starting from an original idea to the construction of a final ready-made and executable experimental solution.

The Miba Machine Shop provides IST Austria's scientists with the best possible support and tools to conduct excellent research. High-end mechanical and electronic machines are at the team's disposal, such as high-precision 3D printers that are used to print unique and complex designs. More details about the Miba Machine Shop's equipment can be found on the SSU website.

The new water jet cutter is another valuable machine that the Miba Machine Shop can now add to its equipment arsenal. A water jet cutter uses a high-pressure water jet to precisely cut and fabricate parts. The new machine will increase efficiency as it saves employees time, cuts materials more precisely, and produces smoother cutout parts for future experiments.

For more information, visit the MIBA Machine Shop website.



IST Lecture by Steven Simon on December 11

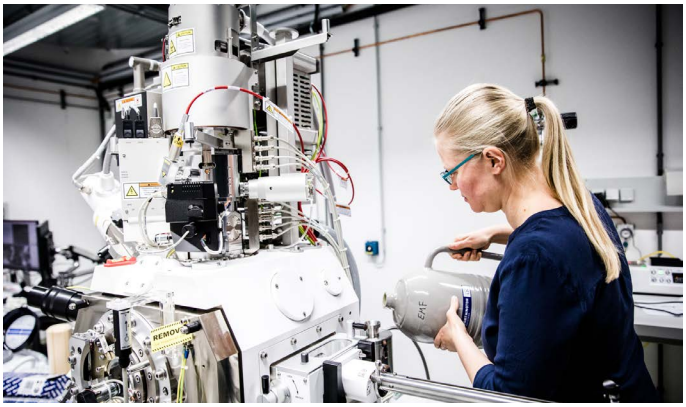
On December 11, Steven Simon will give an IST Lecture on "Topologically Ordered Matter and Why You Should be Interested". Steven H. Simon is a professor of theoretical physics at Oxford University. Formerly a department director at Bell Laboratories, Professor Simon is interested in condensed matter physics, topological quantum effects, quantum information, wireless communications, semiconductor physics, fractional quantum Hall effect and topological quantum computation. His current research focus is on topological phases of matter. He is also the author of a popular introductory book to solid state physics.

To register for the lecture and for more information visit the IST lecture website.

EVENTS - SAVE THE DATE

- Student Open Day (Nov 22, 2019)
- Commemoration lecture by Philipp Ther, University of Vienna (Nov 27, 2019)
- IST Lecture by Steven Simon, Oxford University (Dec 11, 2019)
- "Schärfer als die Physik erlaubt?" Public lecture by Johann G. Danzl (Jan 15, 2020)
- Science Education Day (Mar 11, 2020)
- Science & ... Lecture by Ruth Wodak (Mar 26, 2020)
- Open Campus (Jun 7, 2020)

For more information about future events visit the events website.



Cryo-EM symposium

With three new state-of-the-art cryo-electron microscopes, IST Austria holds the largest and most advanced cryo-electron microscopy (cryo-EM) facility currently being operated in Austria. A one-day symposium highlighted innovative research involving cryo-EM technology, ranging from the latest developments in the field to their application and general biological questions.

Cryo-EM is a cutting-edge technique, where biological samples such as proteins can be observed in their natural state and at near-atomic scales, rendering this method indispensable in structural biology.

COLLOQUIUM SPEAKERS

PAST SPEAKERS: Eve Marder, Brandeis University (Sep 16) | Zeev Rudnick, Tel Aviv University (Sep 23) | Taekjip Ha, Johns Hopkins University (Oct 7) | Jay T. Groves, UC Berkeley (Oct 21) | Ed Boyden, MIT (Nov 4) | Adrian Bird, University of Edinburgh (Nov 11) | Marta Kwiatkowska, Oxford University (Nov 18)

FUTURE SPEAKERS: Nir Shavit, MIT (Nov 25) | Subhash Khot, New York University (Nov 29) | Alex Badyaev, University of Arizona (Dec 16) | Erich Bornberg-Bauer, University of Münster (Jan 13)

SELECTED RECENT PUBLICATIONS

Giese, B., Friess, J. L., Schetelig, M. F., Barton, N. H., Messer, P., Debarre, F., Meimberg, H., Windbichler, N., Boete, C. 2019. Gene Drives: Dynamics and regulatory matters – A report from the workshop "Evaluation of spatial and temporal control of Gene Drives", 4 – 5 April 2019, Vienna. BioEssays

Kopf, A., & Sixt, M. K. 2019. The neural crest pitches in to remove apoptotic debris. Cell, 179(1), 51–53.

Qi, C., Minin, G. D., Vercellino, I., Wutz, A., & Korkhov, V. M. 2019. Structural basis of sterol recognition by human hedgehog receptor PTCH1. Science Advances, 5(9)

Goharshady, A. K., & Mohammadi, F. 2019. An efficient algorithm for computing network reliability in small treewidth. Reliability Engineering and System Safety, 193

Boccato, C., Brennecke, C., Cenatiempo, S., & Schlein, B. 2019. Optimal rate for Bose-Einstein condensation in the Gross-Pitaevskii regime. Communications in Mathematical Physics.

Oliveira, B., Yahya, A. Ç., & Novarino, G. 2019. Modeling cell-cell interactions in the brain using cerebral organoids. Brain Research, 1724

Zhu, Q., Gallemi, M., Pospíšil, J., Žádníková, P., Strnad, M., & Benková, E. 2019. Root gravity response module guides differential growth determining both root bending and apical hook formation in Arabidopsis. Development, 146(17)

Sigalova, O. M., Chaplin, A. V., Bochkareva, O., Shelyakin, P. V., Filaretov, V. A., Akkuratov, E. E., et al. 2019. Chlamydia pan-genomic analysis reveals balance between host adaptation and selective pressure to genome reduction. BMC Genomics, 20(1)

Bornhorst, D., Xia, P., Nakajima, H., Dingare, C., Herzog, W., Lecaudey, V., Mochizuki, N., Heisenberg, C-PJ., Yelon, D., Abdelilah-Seyfried, S. 2019. Biomechanical signaling within the developing zebrafish heart attunes endocardial growth to myocardial chamber dimensions. Nature Communications, 10(1)

Byczkowicz, N., Eshra, A., Montanaro-Punzengruber, J.-C., Trevisiol, A., Hirrlinger, J., Kole, Maarten, H., Shigemoto, R., Hallermann, S. 2019. HCN channel-mediated neuromodulation can control action potential velocity and fidelity in central axons. ELife, 8

Contreras, X., & Hippenmeyer, S. 2019. Memo1 tiles the radial glial cell grid. Neuron, 103(5), 750–752.

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

IMPRINT The IST Austria Newsletter is produced by the Communications team and published every three months. You can find further information about IST Austria on our website (www.ist.ac.at), Facebook (www.facebook.com/istaustria), Twitter (www.twitter.com/istaustria) and Instagram (www.instagram.com/ist_austria).