NEWSLETTER

27th edition | Winter 2018

IST AUSTRIA
Institute of Science and Technology

Foreword

I am a British mathematician who recently relocated to IST Austria from the University of Bristol, where I was heading the Pure Mathematics Institute for several years. You may see me around campus with a child on my bike or an indefatigable dog on a lead (or both), as I live not far from campus in Maria Gugging. I have successfully swapped a hectic commute through uncompromising traffic for a gentle stroll through a farmer's field.

I finished my PhD in Oxford in 2002 under the supervision of Professor Heath-Brown, where I was given the equation $x^5+y^5=u^5+v^5$ to think about. Inspired by Fermat's last theorem, Euler conjectured in the 1760s that the only whole number solutions to this equation are the obvious ones (e.g. $x=y$ and $u=v$). I was not able to make much progress on this problem then, but it started a train of thought that has led me to think deeply about classifying the zoo of polynomial equations that are susceptible to analysis with today's techniques. This has yielded a rich seam of research that, under the umbrella of number theory, brings together strands of geometry, analysis, algebra, and combinatorics.

I arrived at IST Austria more than two months ago, where I have been extremely impressed with the efficacy of the administrative teams and the warm welcome that I have been met with. Now I look forward to building up my research group and contributing to the uniquely dynamic intellectual environment that IST Austria represents and which attracted my attention in the first place.

Tim Browning | Professor, IST Austria

IST Austria is in first place at the European Research Council

At a conference on the occasion of Austria's Presidency of the EU Council, European Research Council President Jean-Pierre Bourguignon announced that IST Austria has, with 48%, by far the highest success rate among European institutions with more than 30 ERC Grants. IST Austria is ahead of renowned research institutions such as the Weizmann Institute (35%), ETH Zurich (29%), the Universities of Cambridge (23%) and Oxford (19%) or the Max Planck Society (22%). The average success rate currently lies at around 13%.

ERC grants are not only an important instrument for financing outstanding research projects, but also an indicator of scientific excellence due to their highly competitive nature. The ranking above is determined by the approval rate of the project proposals, i.e. how many of the submitted projects of a research institution are approved by the ERC. In this respect, IST Austria is more than ten percentage points ahead.

nature INDEX

Nature Index sees Austria in the fast line of science

Nature Index published the results of a study aimed at identifying those institutions and countries that are in the fast lane scientifically. The positive result: Austria is among the six countries in the world with the highest absolute and relative increase in output from 2015 to 2017. "This is an extremely pleasing finding because the Nature Index provides us with objective confirmation that Austria as a science location is developing extremely well and that its scientific productivity is increasing," commented Science Minister Heinz Faßmann.

Among the research institutes younger than 30 years, IST Austria is in 8th place worldwide and the only institute outside Asia to be in the top 10. "In the first years of its existence, our campus has developed into an extremely productive place for basic research of the highest quality. The feedback from Nature Index is an indication that we are on the right track and that our ambitious goals are realistic," said IST President Thomas Henzinger.

Fifth laboratory building to expand IST Austria campus

Since the opening of IST Austria in 2009, the campus in Lower Austria, just outside Vienna, has developed at considerable speed. The campus for the natural sciences, mathematics and computer sciences now provides a workplace for almost 700 employees and the necessary infrastructure for cutting-edge research at the highest level. The expansion of the Institute, which was identified as a "Rising Star" by the Nature Index this year, will continue at a rapid pace over the next few years.

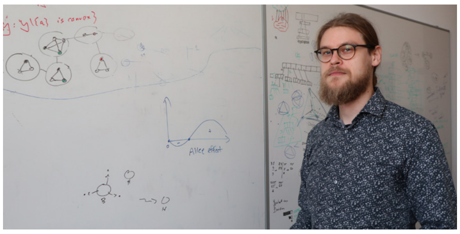
The building projects of the next few years were presented at the ground-breaking ceremony for the fifth laboratory building in October 2018. Maria Ibáñez, Professor at IST Austria since September 2018, will be the first user of the future fifth laboratory building. She presented her research projects in the field of functional nanomaterials, which lies at the interface of material science and chemistry. The ambitious plan is to open the fifth laboratory building in 2020.

Genes responsible for differences in snapdragon flower color identified

Snapdragons are tall, charming plants, and flower in a range of bright colors. In Spain, where snapdragons grow wild, these flower colors show a remarkable pattern: When driving up a road from Barcelona to the Pyrenees, snapdragons of the species *Antirrhinum majus* bloom in magenta at the beginning of the road, before a population of yellow flowering snapdragons takes over – separated by just two kilometers in which the flower colors mix. IST Austria Professor Nick Barton, together with David Field, assistant professor at the University of Vienna, collaborated with molecular geneticists at the John Innes Center to investigate the causes of this pattern.

The researchers compared the genome sequences of 50 snapdragons of each color, and measured how much the sequences diverged between magenta and yellow snapdragon populations. By plotting a statistical measure of divergence between the two populations, they found "islands" in the genome that are more divergent between yellow and magenta snapdragons than the rest of the genome. In the snapdragons, these islands correspond to genes responsible for flower color. Their PNAS paper focuses on two of those genes, which determine the magenta pigment and are located close together on the genome.

The scientists wanted to know how the two snapdragon populations become different. They found two reasons why the snapdragon populations diverge at the flower color genes. First, selection has favored new variants of the color genes that make the flowers more attractive to bees. Secondly, the flower genes become barriers to gene exchange. Any genes located close to or even between the flower genes cannot easily be swapped between the populations, and so the region of genome around the genes that determine flower color become divergent.



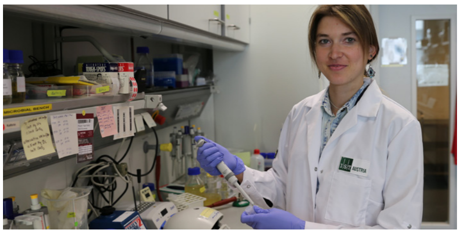
Mathematical model explains why bacteria make us sick in small doses

A few *Shigella* bacteria are enough to make anyone catch gastroenteritis, while to get sick from cholera, thousands to millions of *Vibrio cholerae* bacteria must be swallowed. Based on observational data, biologists have previously proposed that this difference could be due to how bacteria attack their hosts: For example, while *Shigella* bacteria act locally by directly injecting proteins into host cells, cholera bacteria attack from a distance by secreting cholera toxin.

Joel Rybicki, postdoc at IST Austria, and his colleagues Eva Kisdi and Jani Anttila at the University of Helsinki built a mathematical model of bacterial infections. Published in PNAS, their results support the hypothesis that the scale of pathogenetic mechanisms is the reason different bacteria have different infective doses. They predict that the mechanism also influences how quickly an infection spreads in the host.

The scientists devised a mathematical model that reflects bacterial infections. Compared with real-life bacteria, this "theoretical" bacterium allows the researchers to change just one aspect of the bacterium, in this case the mechanism of pathogenesis, while keeping all other aspects the same—a feat that would be difficult, if not impossible, to accomplish experimentally. In this case, the researchers can alter the mechanism of pathogenesis, and seamlessly dial up and down the distance at which the bacterium acts to attack the host and evade the immune system.

The model shows that there is a threshold for infective doses. A bacterium that uses a spreading toxin is defenseless once the toxin it produces disperses, and the immune system can attack. The bacterium is only protected when there are sufficient numbers of nearby bacteria also releasing the toxin.



Biophysical constraints on evolvability and robustness uncovered

It is often thought that DNA, together with the genes encoded in it, is the essence of life. But equally important is the coordination of turning genes on and off. In fact, it is this process, called regulation of gene expression, that defines life by allowing organisms to react to their surroundings rather than being static automatons. As even the smallest organisms like bacteria have many genes, coordinating their expression is done by a dedicated set of proteins, which bind specific sites in the DNA called "promoters" in order to turn genes on or off. Each such pairing between a protein and its associated promoter constitutes one of myriad connections in the organismal gene regulatory network.

Gene regulatory networks are intricately tuned, so how can they evolve and change? In a study published in Nature Ecology and Evolution, a team of researchers at IST Austria, including co-first authors Claudia Igler and Mato Lagator, as well as Calin Guet, Gašper Tkačik and Jonathan Bollback (University of Liverpool), described how individual regulatory connections can change over time.

Instead of analyzing gene regulatory networks at the global level, the researchers decided to study network evolution from the local perspective in order to understand how connections in the network change. To do so, they used two DNA-binding proteins and their associated promoters. These proteins are called 'repressors', as their binding to DNA inhibits gene expression. The scientists then introduced mutations into the promoters and observed how these changes affected the binding of repressors. Comparing between the two studied repressors, they found that the more robust repressor acquired binding to new promoters more readily. By developing a biophysical model based on the thermodynamics of protein-DNA binding, they were not only able to explain their surprising observations, but could generalize their findings.

Chris Wojtan, Computer Scientist

What was your original field of study? I studied at the University of Illinois for my undergraduate degree, I got a bachelor's degree there, and then did my PhD in computer science with a minor in physics at Georgia Tech.

Why did you become a scientist? My first exciting moment was in high school, when I was introduced to physics, which can perfectly describe the motion of objects with mathematical equations. As an undergraduate, I realized people were doing research in computer graphics, which used equations from physics to move things in a virtual world. If you do this well enough, you can have an entire universe inside a computer, obeying your commands.

What do you like about basic research? In basic research you can ask fundamental questions, which often lead to very surprising answers. When you ask basic questions, you gain a fundamentally new understanding of something, and you have the potential to make a huge leap forward in the field because you discover something nobody else was even thinking about.

What is your main area of research? My area of research is computer graphics, specifically physics-based animation. The idea is to take equations from physics that are very hard to solve, use computers and mathematical techniques to solve them as best as we can, and use these beautiful results to enhance video games, special effects or virtual worlds, or to increase our knowledge of physics by using these computations to give us new ideas.

Which scientific result are you particularly proud of? One of the results that I am proud of is a method of simulating water waves in an extremely efficient manner at large scales. Instead of thinking about each individual ripple, we made equations about groups of ripples which can be simulated at a much larger scale just as accurately. As a result, we have the first method that can simulate extremely large-scale oceans at real-time rates, which makes it suitable for virtual reality and other interactive applications. We are excited because it is one of these big leaps that a lot of people will jump on.

What is special about IST Austria? One of the things that is special about IST Austria is the freedom we have here. We are free to pursue any questions that interest us. We can ask fundamental questions that might be difficult to solve. We might ask questions that might seem irrelevant but might have surprisingly useful answers. We can make large leaps in the state of the art because we can afford to take risks.

What will IST Austria look like in ten years? I have been at IST Austria for about seven years now. Since then, it has quintupled in size. In the next 10 years, I expect another huge increase. With that will come a change in culture. And it will have very interesting effects on interdisciplinarity. But at the same time, it will also have strong effects on the concentration of quality. In 10 years, it will be small enough to have bridges of interdisciplinarity across different fields while simultaneously having very strong concentrations of fantastic science being done at IST Austria.

Watch the entire ProfTalk interview on video!

More space for fish and plants

IST Austria is growing, not just in the number of scientists, but also in the number of experimental organisms on campus. The Life Science Facility houses and takes care of zebrafish and plants used in experiments at IST Austria. In the past months, however, the zebrafish and *Arabidopsis plants* outgrew their homes. To provide more space for fish and plants, the existing facilities were extended.

Arabidopsis thaliana is a hardy plant usually found by the side of the road. Also known as thale cress, it is a favorite among plant biologists. At IST Austria, the groups of Eva Benková and Jiři Friml use *Arabidopsis* to study how plant hormones influence the way in which plants grow. So far, the groups' experimental plants were housed in two growth chambers in the basement of the Central Building. These two rooms, and an experimental area connecting them, had space for 266 trays of *Arabidopsis* plants and were filled to 90% capacity in the past years.

To ease the space problem and allow scientists to work with even more plants, a nearby former storage room was adapted as a plant growth chamber. This adaptation represented true teamwork between different divisions at IST Austria: the Machine Shop adapted the shelfing system, the construction team installed new LEDs and a specialized air-conditioning system, and H_2O_2 from the Preclinical Facility was used to sterilize the room. Now, the former storage room has 120 spaces for plant trays, reaching up to the ceiling, and the first plants have moved into their new home.

The zebrafish in the fish facility also got new tanks. Zebrafish are a popular model organism for studying animal development and, at IST Austria, are mainly used by the Heisenberg Group. The new system has 200 tanks, which can each hold a fish swarm of up to twenty animals. They are also easier to clean than the existing tanks. In the past years,

the fish facility operated at 90% capacity. With the new extension, the fish facility can house up to 70'000 fish and the first fish are already exploring the new tanks.

The Life Science Facility is one of eight Scientific Service Units currently established at IST Austria. Its team supports experimental biologists in their research work and provides laboratory infrastructure that enables scientists to use a broad spectrum of standard and advanced technologies in their work. They supply experimental resources at a consistently high level to allow the scientists to focus on their scientific questions as much as possible. Further information can be found on the Scientific Service Units website.

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Student Open Day 2018

IST Austria welcomes prospective students to the Student Open Day on Friday, November 30th 2018! This is the day where they can visit IST Austria to find out which research groups they could do a PhD or internship with and how to apply to the Graduate School.

Visitors will get the chance to meet the research groups through lab tours and “Meet the Research Group” sessions, organized by our professors, PhD students, and postdocs. They can also discover the campus through a campus tour and learn about the history and future of IST Austria. In addition, there will be an information session about the PhD program and internship opportunities at IST Austria. For more information visit the website.

VI. CENTRAL EUROPEAN MEETING
IUSSI 2019
Institute of Science and Technology Austria

Central European Meeting of the IUSSI 2019

The 2019 Conference of the Central European Section of the International Union for the Study of Social Insects (IUSSI) and a Social Immunity Workshop will be held at IST Austria on March 19-22 2019. The CE IUSSI conference is a biennial meeting that brings together researchers interested in the ecology and evolution of social insects.

The workshop will introduce the concept of collective disease defense in social insects, present methods for the study of disease and insect immunity, and give hands-on insights into experimental work on ant-pathogen interactions. It is aimed at the PhD and postdoctoral level and will involve discussion rounds and a visit to the social immunity laboratory. For more information visit the website.

COLLOQUIUM SPEAKERS

PAST SPEAKERS: Gil Kalai, Hebrew University of Jerusalem (Sept 3) | Orna Kupferman, Hebrew University of Jerusalem (Sept 10) | John O’Keefe, University College London (Sept 17) | Wolf Singer, Max Planck Institute for Brain Research (Sept 24) | Grant Jensen, Caltech (Oct 1) | Immanuel Bloch, Ludwig Maximilian University of Munich (Oct 29) | Michel Milinkovitch, University of Geneva (Nov 5) | Monika Henzinger, University of Vienna (Nov 12) | Molly Przeworski, Columbia University (Nov 19)

FUTURE SPEAKERS: Michael Brenner, Harvard University (Nov 26) | Arthur D. Lander, University of California, Irvine (Dec 17)

SELECTED RECENT PUBLICATIONS

Auzinger T, Heidrich W, Bickel B. 2018. Computational design of nanostructural color for additive manufacturing. ACM Transactions on Graphics. 37(4), 159:1-159:16.

Chatterjee K, Goharshady A K, Ibsen-Jensen R, Velner Y. 2018. Ergodic mean-payo games for the analysis of attacks in crypto-currencies. CONCUR: Conference on Concurrency Theory. LIPIcs vol. 118. Article number: 11.

Deuchert A, Seiringer R, Yngvason J. 2018. Bose–Einstein condensation in a dilute, trapped gas at positive temperature. Communications in Mathematical Physics., epub ahead of print.

Edelsbrunner H, Nikitenko A. 2018. Random inscribed polytopes have similar radius functions as Poisson-Delaunay mosaics. Annals of Applied Probability. 28 (5), 3215-3238.

Fiedorczuk K, Sazanov LA. 2018. Mammalian mitochondrial complex I structure and disease causing mutations. Trends in Cell Biology, ePub ahead of print.

Fischer J, Kneuss O. 2018. Bi-Sobolev solutions to the prescribed Jacobian inequality in the plane with L p data and applications to nonlinear elasticity. Journal of Differential Equations., epub ahead of print.

Kragl B, Qadeer S, Henzinger TA. 2018. Synchronizing the Asynchronous. CONCUR: International Conference on Concurrency Theory. LIPIcs vol. 118. 21:1-21:17.

Nejjar P. 2018. Transition to shocks in TASEP and decoupling of last passage times. ArXiv, Preprint.

Nikolic N. 2018. Autoregulation of bacterial gene expression: lessons from the MazEF toxin–antitoxin system. Current Genetics, epub ahead of print.

Picard MA, Cosseau C, Ferré S, Quack T, Grevelding CG, Couté Y, Vicoso B. 2018. Evolution of gene dosage on the Z-chromosome of schistosome parasites. eLife. 7, Article number e35684.

Renkawitz J, Reversat A, Leithner. Alex, Merrin J, Sixt M. 2018. Micro-engineered “pillar forests” to study cell migration in complex but controlled 3D environments. Methods in Cell Biology, epub ahead of print.

Sachdeva H, Barton NH. 2018. Introgression of a block of genome under infinitesimal selection. Genetics. 209(4), 1279-1303.

Watzinger H, Kukučka J, Vukušić L, Gao F, Wang T, Schäffler F, Zhang J, Katsaros G. 2018. A germanium hole spin qubit. Nature Communications. 9 (3902), Article number: 3902 (2018).

A full list of publications from IST Austria can be found at publist.ist.ac.at.

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