FLOW
In 2013, the research directions at IST Austria expanded to include physics, studying—among other topics—fluid turbulence. Thus 'flow' has been chosen as theme for the 2013 annual report.

At IST Austria the steady flow of ideas between researchers of different disciplines is stimulated by physical connections, such as the campus bridge, a meeting space between buildings. A room-length blackboard on the bridge bears witness to the continuous exchange of ideas and concepts, and inspired the design of this report.

<table>
<thead>
<tr>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>forewords</td>
</tr>
<tr>
<td>03 Foreword by the President</td>
</tr>
<tr>
<td>05 Foreword by the Vice-Chair, Board of Trustees</td>
</tr>
<tr>
<td>the institute</td>
</tr>
<tr>
<td>06 IST Austria at a glance</td>
</tr>
<tr>
<td>08 Career model of IST Austria</td>
</tr>
<tr>
<td>10 The IST Austria Graduate School</td>
</tr>
<tr>
<td>12 Postdoctoral education</td>
</tr>
<tr>
<td>research</td>
</tr>
<tr>
<td>14 Research highlight: Computer Science at IST Austria</td>
</tr>
<tr>
<td>16 Current research at IST Austria</td>
</tr>
<tr>
<td>18 Barton Group</td>
</tr>
<tr>
<td>19 Berkovits Group</td>
</tr>
<tr>
<td>20 Bobbink Group</td>
</tr>
<tr>
<td>21 Boichenbach Group</td>
</tr>
<tr>
<td>22 Chatterjee Group</td>
</tr>
<tr>
<td>23 Cimrman Group</td>
</tr>
<tr>
<td>24 Cicconati Group</td>
</tr>
<tr>
<td>25 Eckstein Group</td>
</tr>
<tr>
<td>26 Endl Group</td>
</tr>
<tr>
<td>27 Frits Group</td>
</tr>
<tr>
<td>28 Guent Group</td>
</tr>
<tr>
<td>29 Heisenberg Group</td>
</tr>
<tr>
<td>30 Hezelinger Group</td>
</tr>
<tr>
<td>31 Hippenmeyer Group</td>
</tr>
<tr>
<td>32 Hof Group</td>
</tr>
<tr>
<td>33 Janovjak Group</td>
</tr>
<tr>
<td>34 Jonas Group</td>
</tr>
<tr>
<td>35 Komarova Group</td>
</tr>
<tr>
<td>36 Lämmer Group</td>
</tr>
<tr>
<td>37 Patrak Group</td>
</tr>
<tr>
<td>38 Raven Group</td>
</tr>
<tr>
<td>39 Shipman Group</td>
</tr>
<tr>
<td>40 Siewicz Group</td>
</tr>
<tr>
<td>41 Sinti Group</td>
</tr>
<tr>
<td>42 Tkacik Group</td>
</tr>
<tr>
<td>43 Uhrer Group</td>
</tr>
<tr>
<td>44 Wagner Group</td>
</tr>
<tr>
<td>45 Wolfs Group</td>
</tr>
<tr>
<td>46 IST Austria professors 2014 &amp; 2015</td>
</tr>
<tr>
<td>47 Research grants 2013</td>
</tr>
<tr>
<td>49 Publications 2013</td>
</tr>
<tr>
<td>outreach</td>
</tr>
<tr>
<td>54 Scientific events</td>
</tr>
<tr>
<td>56 Communicating science</td>
</tr>
<tr>
<td>organization</td>
</tr>
<tr>
<td>58 Diverse funds</td>
</tr>
<tr>
<td>58 Boards of IST Austria</td>
</tr>
<tr>
<td>60 Administration</td>
</tr>
<tr>
<td>62 Scientific service units</td>
</tr>
<tr>
<td>campus</td>
</tr>
<tr>
<td>64 Location &amp; directions</td>
</tr>
<tr>
<td>66 Flowing progress: winter impressions</td>
</tr>
</tbody>
</table>
2013 was a year of strong growth for IST Austria. Six new research groups started their work on campus, bringing the total number of groups at the Institute to 28, half of them funded by coveted ERC grants of the European Union. With the 29 new PhD students who joined the IST Graduate School at the start of the new academic year, there are now more than 200 scientists on campus. Overall, more than 370 employees from over 50 countries work at IST Austria.

The scientific scope of IST Austria also expanded in 2013. Several groups now perform research in physics: mathematical physics, biophysics, and fluid dynamics. The Institute’s activities in the life sciences also expanded into plant biology. Over the course of the year, the scientists of IST Austria published more than 160 refereed journal and conference papers and acquired more than 9 million Euro in new research funds. The first assistant professor, Michael Sixt, went through a tenure evaluation by international experts and was promoted to professor. The first PhD graduate who began his studies at IST Austria, Damien Zufferey, is now a postdoc at MIT. Several IST Austria postdocs succeeded in obtaining faculty positions.

As the scope of the research activities expanded at IST Austria, also the supporting infrastructure grew accordingly. A new electron microscopy facility was established and the lab support facility expanded from biology to physics. In the name of all scientists, I thank the new managing director Georg Schneider and the entire dedicated team of scientific and administrative support personnel. They make it possible that our researchers compete successfully against the leading institutions in the world, both in extending the frontiers of human knowledge and in training future generations of scientists.

IST Austria cannot succeed without its many supporters. Six of our most promising PhD students received scholarships by our donors OMV and Steven Heinz. The IST Austria machine shop for building electronic and mechanical setups for our scientists was officially named the Miba machine shop, appreciating Miba’s generous support of the Institute. I thank all supporters and friends of IST Austria, especially the former Federal Minister for Science and Research, Karlheinz Töchterle, and the Governor of Lower Austria, Erwin Pröll. IST Austria proves that ambitious projects can succeed if politics provides the necessary firm and long-term commitment.
From the beginning, it was clear that the new institute should be a postgraduate research institute, and that the Weizmann Institute of Science in Israel was an institution to be compared with. It was part of the concept from early on that the new institute should be dedicated to the basic sciences, performing interdisciplinary research with a focus on mathematics, physics, chemistry and biology.

Today, IST Austria shows that these dreams have become reality. This was possible by uncompromisingly following a few fundamental principles. The most important ones are: No political involvement in any academic affairs, including the selection of the president and key decision makers. Attract the most interesting professors available, solely on the basis of their qualification. Avoid filling positions in a pre-defined research direction. And, have clear internal policies, the most important being the limit of the size of each research group. This avoids that a senior professor becomes mainly a group’s manager. Other key policies are: Strong focus on interdisciplinary research, recruitment of students on the highest international level, and getting top advice both from various committees within the Institute and from the outside.

A very challenging and sometimes arduous road had to be travelled in the first few years of the fledgling idea. In the end, it was possible to convince the important decision makers that the idea is worthwhile. In Vienna, we need a similar institution.”

Reinhold Mitterlehner
Federal Minister of Science, Research and Economy

“IST Austria is by definition an institute for basic research, which intrinsically means that the research is driven solely by the curiosity of the scientists. Nevertheless, its founding fathers in the very beginning provided the plans to enable a profitable utilisation of scientific findings. In this farsighted framework the requirements of science and industry are considered equally. This equips IST Austria to pursue its strategy of excellence in a highly competitive environment.”

Erwin Pröll
Governor of Lower Austria

“IST Austria proves that the transformation of a region can be achieved by adhering to a long-term strategy of excellence implemented by an outstanding leadership and a highly skilled and motivated work force based on a bold vision of change.”

Erwin Pröll
Governor of Lower Austria

In 2013 the idea of IST Austria celebrated its tenth anniversary. In March 2003, I participated at MIPIM, the International Real Estate Show in Cannes, to make a point for the Vienna region as a hub for science and technology. There, I made the first public proposal to create what eventually became IST Austria: “When you tell a taxi driver in Boston that you want to go to MIT, he is impressed. In Vienna, we need a similar institution.”

Anton Zeilinger
Vice-Chair, Board of Trustees of IST Austria
President, Austrian Academy of Sciences

"IST Austria proves that the transformation of a region can be achieved by adhering to a long-term strategy of excellence implemented by an outstanding leadership and a highly skilled and motivated work force based on a bold vision of change.”

Erwin Pröll
Governor of Lower Austria

To the success of IST Austria sets an example for other institutions in Austria and beyond. The success, as always, depends on the framework conditions, of which the financial supply to tertiary and postgraduate education at an internationally competitive level is a vital requirement. The very fact that it was possible to create IST Austria carries very high compliments for the level of political debate and for the decision making processes in this country.

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IST Austria

at a glance

The Institute of Science and Technology Austria (IST Austria) is a multidisciplinary research institution dedicated to cutting-edge basic research in the natural, mathematical, and computer sciences.

Diverse funding

The long-term financial viability of IST Austria relies on four sources of funding: public funding, international and national research grants, technology licensing, and donations. For the period from 2007 until 2026, the federal government of Austria provides up to 1.28 billion Euro in operational funds. Two thirds of this budget are guaranteed, while the remaining third is conditioned on performance-related criteria such as the raising of third-party funds.

The state of Lower Austria contributes the budget for construction and campus maintenance, in a total amount of 510 million Euro from 2007 until 2026. By the end of 2013, IST Austria has obtained commitments for more than 36 million Euro in research grants, the vast majority of which originates from sources outside of Austria. The Institute holds the rights to all research results and discoveries of its scientists and is committed to promote their use through technology licensing. IST Austria is also active in fundraising and, by the end of 2013, has received more than 17 million Euro in donations.

Independent leadership

The governance and management structures of IST Austria guarantee the Institute’s freedom from political and commercial influences. The Institute and its scientific fields are evaluated regularly by leading international scientists and science administrators. In 2013, the seven computer science groups of IST Austria were evaluated. IST Austria is headed by the President, who is appointed by the Board of Trustees and advised by the Scientific Board. The first President of the Institute is Thomas A. Henzinger, a computer scientist and former professor of the University of California at Berkeley and the EPFL in Lausanne, Switzerland, who started his second term in 2013. The administration of IST Austria is led by the Managing Director, Georg Schneider.

Up-to-date information on IST Austria can be found at www.ist.ac.at, where it is possible to sign up for the Institute’s quarterly newsletter.
The steps of an international scientific career are similar for young researchers all over the world. Accordingly, the scientists of IST Austria are at one of the following four stages: PhD student in the graduate school, postdoc, assistant professor (tenure track), and professor. While PhD students and postdocs leave IST Austria to pursue the next steps of their careers at other institutions, assistant professors may be promoted to professor, dependent on an evaluation of their scientific achievements. In 2013, all career transitions were accomplished by scientists of IST Austria.

More than a third of the scientists at IST Austria are doctoral students. They take advanced courses and perform research supervised by an assistant professor or professor. IST Austria puts much emphasis on the education of its graduates, as the reputation of IST Austria will depend crucially on the future success of the scientists it trains.

Damien Zufferey joined the IST Austria graduate school in September 2009, as one of the first intakes of graduate students. Damien pursued research on the verification of message passing programs and successfully passed his thesis defense in August 2013. Damien moved to a postdoc position at MIT, where he now works in the Computer Science and Artificial Intelligence Laboratory.

In the next career stage, postdocs perform partly independent research, still under the supervision of a group leader. It is important for the education of a scientist that the undergraduate, doctoral, and postdoc stages happen at different institutions, so that the young researcher gets exposed to a variety of scientific approaches, methods, and cultures. After a few years of postdoc experience, the goal of a successful young scientist is to obtain a fully independent researcher position.

In 2013, Pavol Cerny, who had been a postdoc in the group of Thomas Henzinger since 2009, became assistant professor at the University of Colorado in Boulder. Gaia Novarino, an Italian neuroscientist performing postdoctoral research at the University of California in San Diego, was hired as assistant professor at IST Austria and will move to the IST Austria campus at the beginning of 2014. Gaia Novarino’s research aims to identify and study genes that underlie inherited forms of epilepsy associated with intellectual disability and/or autism.

Michael Sixt, who joined IST Austria as assistant professor in 2010, was the first to go through the tenure evaluation. During the evaluation, international experts are consulted to judge the research achievements of the assistant professor, but also performance with regards to the other duties of a successful scientist play a role, such as teaching, supervision of PhD students and postdocs, service to the Institute and to the international scientific community. Michael Sixt, a cell biologist, was promoted to professor in the fall of 2013. He aims to understand the molecular and mechanical principles of cell motility at both the cellular and tissue level.

IST Austria recruits young group leaders as assistant professors, gives them complete scientific independence during the most creative years in a researcher’s career, and promises them the opportunity to be promoted to professor based solely on an independent evaluation of their scientific performance. In 2013, both steps of this tenure track model were taken at IST Austria.

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From PhD students to postdocs and professors, IST Austria is committed to promoting the international success of its researchers at all stages of their career.
The Institute

11

The IST Austria Graduate School

A flow of education

The IST Austria Graduate School offers a first step into scientific careers in the life sciences, computer sciences, mathematics, physics, and any related interdisciplinary areas. Highly qualified students with a bachelor’s or master’s degree seeking to start their scientific career in an international environment are invited to apply for our unique multidisciplinary PhD program.

81 students from 28 countries

In 2013, its fourth year of operation, the IST Austria graduate school had its largest intake of new PhD students yet: of more than 330 applicants from 57 countries, 29 new PhD students were selected and started their doctoral studies at IST Austria in September 2013. The newest class of PhD students, among them 7 Austrians, comes from 14 different countries. Currently, 81 PhD students from 28 nations work at IST Austria. All PhD students are chosen once a year in a competitive selection process (the application deadline is always January 15). The entire IST Austria faculty evaluates the applications, as prospective students need not identify a potential supervisor when applying. All PhD students are offered employment contracts with an internationally competitive full-time salary.

A multidisciplinary PhD program

Owing to the interdisciplinary research culture at IST Austria, a single joint graduate program is offered for all PhD students. The graduate school trains a new generation of researchers who are able to approach scientific questions from different angles and are fluent in the languages of both the experimental sciences and the analytical sciences. The PhD program is divided into two phases. During the first phase, students carry out projects with three different research groups and attend courses from the entire range of scientific fields represented at IST Austria. This phase, which typically lasts one year, offers students the opportunity to work closely with several professors, while the interdisciplinary curriculum gives students both breadth and depth to their scientific education. After successfully presenting their research proposal in a qualifying exam, students enter the second phase of the program, during which they focus on research towards a doctoral thesis. After a successful thesis defense, the student receives a PhD degree from IST Austria.

Graduate student association

The PhD students of IST Austria are organized in the Graduate Student Association (GSA), which, as an interface between graduate students, administration, and faculty, represents the students’ interests and provides feedback from the students’ perspective. As a platform for exchanging opinions and promoting interactions, the GSA also organizes social and work-related events. In 2013, these included a retreat for PhD students to Slovakia, a welcome BBQ for arriving students, career development workshops and seminars, as well as events with students from other universities. A day at a climbing park provided an opportunity to meet fellow students while sharing the adrenaline kick of high ropes and flying foxes. The GSA plays a vital role in bringing together students from different research groups and disciplines and creating a lively atmosphere on campus.

Scholarships

Six students who started their degree in September 2013 received a special honor at the very beginning of their scientific career: they were chosen as named scholars, meaning that two donors financially support their study. As of 2013, Steven Heinze, Austrian co-founder of the investment company Lansdowne Partners and Managing Director of Lansdowne Partners Austria GmbH, supports IST Austria’s scholarship program with €120,000. The Vienna-based oil and gas company OMV has been supporting IST Austria since 2008, and contributions to the scholarship program are part of this support. The six especially promising doctoral students were chosen by a jury consisting of IST Austria postdocs, based on their achievements as undergraduate students.

Key Features

Entry with a bachelor’s or master’s degree
Multidisciplinary, US-style graduate school
Central admissions process once a year

Admissions

Annual call for applications starts November 15
Open day for prospective applicants in November
Application deadline January 15
Visit day for shortlisted candidates in March
PhD program starts September 15

see www.ist.ac.at for further information on PhD applications
Postdoctoral flow

Excellent young scientists who have obtained a doctoral degree elsewhere are supported at IST Austria throughout the early stage of their research career as postdocs. At the end of 2013, 100 postdocs pursued research at the Institute. Highly qualified recent PhD graduates in the natural sciences, computer science, mathematics, or any related discipline are encouraged to apply for a postdoctoral position with the faculty of IST Austria.

Applications for postdoctoral appointments are accepted on a continuous basis and decided by the research group leaders. Appointments can last for a period of up to four years.

The ISTFELLOW program
In addition to postdocs accepted by individual research groups, IST Austria has set up the ISTFELLOW program for exceptional postdoctoral researchers with a higher degree of independence. ISTFELLOW is partially funded by the European Union through a Marie-Curie Action COFUND grant. Over a period of five years, ISTFELLOW will support 40 international postdoctoral fellows for two years each; a prolongation for another two years is possible through the support of an IST Austria professor. ISTFELLOW places an emphasis on cross-disciplinary scientific approaches and is open to qualified applicants from all over the world.

The main selection criteria for ISTFELLOW are scientific excellence and promise. Applications for ISTFELLOW are accepted at any time, but the selection of fellows takes place twice a year, in October and April.

www.ist.ac.at/research/postdoctoral-research/how-to-apply/

Postdoc association
The postdoctoral researchers of IST Austria are represented by the Postdoctoral Association (PDA), whose goal is to support and improve the postdocs’ research and social environment on campus. The PDA organizes social events for postdocs including barbecues and regular get-togethers, as well as work-related events such as career-planning and grant-writing workshops.

First steps for young scientists

Young Scientist Symposium
Because of its overwhelming success when first introduced in 2012, a Young Scientist Symposium was organized again jointly by the postdocs and PhD students in 2013. This year’s one-day symposium, on “Understanding shape: in silico and in vivo”, explored the concept of shape and how to deal with it, bringing together alternative views from different areas of research, including mathematics, computer science, and the life sciences. The multidisciplinary symposium featured six world-class speakers - Ed Connor, Robert Černy, Vittorio Ferrari, Massimo Ferri, Chaim Goodman-Strauss, and Isaac Salazar-Ciudad - and attracted an interdisciplinary audience from the Vienna region. The expert talks were followed by a panel discussion and lively discussions in a relaxed atmosphere.

The ISTernship program
ISTernship is a new program aimed at outstanding undergraduate students who wish to spend part of the summer at IST Austria to perform basic research with one of our research groups. ISTerns work on a research project for two to three months under the close supervision of a faculty member and a lab mentor. In the summer of 2013, 16 interns took part in the ISTernship program, which culminated in a research symposium where they presented their work. The application is open to students within the final two years of a bachelor’s or master’s program at Austrian and international universities. The deadline for applications is February 15.

www.ist.ac.at/research/isternship/applications/
As different as their research areas are, all computer scientists at IST Austria pursue their research emphasizing the mathematics behind their subjects and perform their work on a solid foundation of mathematical rigor. A driving force in their work is an interdisciplinary outlook, as they look for joint efforts both between different areas of computer science and with other disciplines of the natural sciences. The mathematics used, and the concepts explored at IST Austria span a wide spectrum, from the discrete to the continuous. Also in the range from theory to application, computer scientists at IST Austria can be found at both ends, and at many steps in between.

Safe software
The groups of Krishnendu Chatterjee and Thomas Henzinger perform research on the formal verification of computer programs. This research area aims to improve the quality of software by preventing programming errors, or at least detecting them before they do harm. At IST Austria, they look for joint efforts both between different areas of computer science and with other disciplines of the natural sciences. The mathematics used, and the concepts explored at IST Austria span a wide spectrum, from the discrete to the continuous. Also in the range from theory to application, computer scientists at IST Austria can be found at both ends, and at many steps in between.

The Henzinger group works to prevent and reduce programming bugs in parallel and embedded software processes, which often control physical devices and are particularly error-prone and safety-critical. To improve the reliability of such cyber-physical systems, the Henzinger group develops new theories, algorithms, and programming tools—based on mathematical logic and formal languages—for error detection in computer programs and for the error-free design of hardware and software and their interaction. Their stochastic mathematical models for capturing and analyzing the behavior of software processes that interact with each other are also used to predict the behavior of molecular and cellular processes, such as biochemical reaction networks.

Visual Computing
Vladimir Kolmogorov and Christoph Lampert employ mathematical methods to make computer scientists understand images. Kolmogorov focuses on algorithms for inference in graphical models, which are frequently used for analyzing images. He works on developing practically efficient techniques to understanding theoretical aspects of discrete optimization. Some of Kolmogorov’s theoretical work can be applied immediately in practical algorithms. Methods and algorithms found by Kolmogorov are widely used by the community, and are included in commercial image segmentation tools. In 2013, Kolmogorov received an ERC grant for his research on discrete optimization in computer vision, which brings the number of computer scientists at IST Austria who are supported by the European Research Council to five.

The Lampart group builds on a different mathematical theory—machine learning—to approach questions in image understanding. In 2013, Lampart started a project that aims to give computers the ability to recognize objects in an image in as much as well as understood what is happening in a scene. The idea behind this project is that a computer can learn continuously and, over time, build up the necessary background knowledge for understanding images, just as humans do when growing up. While the theory of continuous learning is developed in the mathematical framework of machine learning, the knowledge acquired by a program is represented in a way that makes it usable in the future, for example, allowing the computer to know how big objects usually are or which objects are normally found indoors or outdoors.

Moving along the spectrum from having computer scientists understand images to making computers produce images, Chris Wojtan’s research is in computer graphics. He develops algorithms for the computer simulation and visualization of complex physical processes, especially fluid flows. The Wojtan group achieves realistic and physically based animations of liquids, as well as for the efficient rendering of mass and volume in incompressible flows. In 2013, Kolmogorov’s group contributed to two papers presented at the premier international conference in computer graphics. These papers introduced novel techniques for visually rich high-resolution animations of liquids, as well as for the efficient creation of complicated geometry.

As part of its task to control the scientific quality of the Institute, the Scientific Board of IST Austria organizes external evaluations of individual scientific areas present at the Institute. In 2013, computer science was evaluated. As we highlight a scientific area of the Institute in every annual report, we chose computer science this year.

Cryptography
Another field of computer science that has enormous practical relevance is cryptography. This research area aims to ensure that computer scientists can trust and communicate is secure. Using techniques from various mathematical disciplines including information theory, number theory and computational complexity, the Pietrzak group develops cryptographic schemes that can be used on very restricted hardware like RFID tags, for which existing cryptosystems are too complex to be implemented. Another line of research aims at constructing schemes that remain provably secure even against so-called side-channel attacks, in which the attacker exploits information inevitably leaked during a cryptographic computation, for example, by measuring the power consumption or electromagnetic radiation. In 2013, Pietrzak presented a scheme for digital signatures where the signature length is significantly shorter than what was previously possible. Shorter signatures mean less overhead is required for authenticating communication. Com- pact signatures can therefore reduce communication required for authentication—digitally signed documents are sent faster, but can still be trusted.

Computational topology
Straddling both the theoretical and applied sides, Herbert Edelsbrunner’s research lies at the intersection of mathematics and computer science. A common theme in his research is the importance of shape and its recognition, matching, and classification questions that are investigated mostly from the viewpoint of mathematical topology. This research created a new area within mathematics, “computational topology,” which started from work on persistent homology. Today, this vibrant research area encompasses mathematicians, computer scientists, and engineers. The theoretical research at the same time becomes applied, as a range of questions that arise in applications motivates the Edelsbrunner group, for example, the common question of how to define and measure the length of tube-like structures in biological contexts, such as blood vessels, river networks, trees, lymph vessels, dendrites, and more. In 2013, the mathematical work of the Edelsbrunner group contributed to two papers on the growth of plant roots, identifying genes that control root architecture as well as new forms of communication important for root development.
Currently, research at IST Austria focuses on cell biology, physics, mathematics, computer science, evolutionary biology, and neuroscience. There are strong synergies between these fields, and to foster an interdisciplinary spirit, the Institute is not organized into departments.
Mathematical Models of Evolution

Nick Barton

How do new species emerge from a single population? Why do so many organisms reproduce sexually? How quickly can species adapt to changes in conditions? The Barton group develops mathematical models to probe fundamental issues in evolution.

Nick Barton and his group study diverse topics in evolutionary genetics. The main focus of their work is the evolution of populations that are distributed through space and that experience natural selection on many genes. Understanding how species adapt to their environment, and how they split into new species, requires understanding the effects caused by spatial subdivision. The distribution of genes through space can, in turn, tell us about evolutionary processes that are hard to measure directly. The interaction between large numbers of genes is important in the formation of new species as well as in their response to natural and artificial selection. The recent flood of genomic data makes analysis of the interactions amongst large numbers of genes essential, and the Barton group uses mathematical models to make sense of this mass of data and to find answers to fundamental questions of evolution.

Current Projects
- Evolution of sex and recombination
- Evolutionary computation
- Evolution of polygenic traits
- Understanding genealogies in space and at multiple loci
- Limits to a species’ range
- Specialization & hybridization in Antirrhinum

Plant Developmental Biology

Eva Benková

True to their names ‘Greek roots, plant hormones’ ‘set in motion’ a myriad physiological processes. Influencing and modulating each other, an intricate network of interactions arises. The Benková group seeks to untangle this network and understand its molecular basis.

Plant hormones regulate a multitude of processes, often overlapping and modulating their effects. The two hormones auxin and cytokinin show just how complicated these interactions can be: while they act together to promote cell division, they act antagonistically when regulating the lateral growth of roots. How these interactions are regulated on a molecular level is the main question pursued by the Benková group. To understand the components and mechanisms that balance the output of auxin and cytokinin signaling, they use the lateral outgrowth of roots in Arabidopsis as their model system. Recently, the group has shown that an important mode of interaction is the modulation of auxin transport through cytokinin. They now focus on how cytokinin can control the flow of auxin by controlling auxin efflux on the transcriptional and posttranscriptional level. To determine more components of this regulatory pathway, the Benková group applies profiling and genetic screens to investigate the interaction of cytokinin with the cellular endocytotic machinery. Novel cross-talk components will help the group reveal new mechanisms integrating auxin and cytokinin signaling.

Current Projects
- Convergence of hormonal pathways on transport-dependent auxin distribution
- Identification of hormonal cross-talk components by genetic approaches
- Disclosing the molecular network mediating auxin-cytokinin interactions using a transcriptome profiling approach
Microbes can be found everywhere – in the soil, air, water, our food, and even inside of us. The Bollback group uses these ubiquitous organisms to study the process of evolution and to better understand what evolutionary forces have shaped the microbes themselves.

Microbes – viruses, bacteria, Archaea, and protists – account for half of the world’s biomass, the majority of the biological diversity on Earth, and are the culprits of many human diseases. Microbes are also an extraordinarily powerful model system for understanding how evolution works. By studying microbes, the Bollback group addresses a variety of fundamental evolutionary questions. Firstly, how does adaptation differ between sexual and asexual populations? Microbes are mostly asexual, and asexuality slows down the rate of adaptation. Secondly, how do microbes defend themselves against parasites? Microbes, like other organisms, have their own parasites, and are thus a good model system for understanding how evolution works. By studying microbes, the Bollback group addresses a variety of fundamental evolutionary questions. Finally, how does horizontal gene transfer, from other individuals and species, yet it is unclear what evolutionary forces are acting to promote and restrict this process.

Current Projects
- The rate of adaptive evolution in sexual and asexual populations
- The evolution of an adaptive heritable immune system in bacteria

SELECTED PUBLICATIONS

Biophysics and Systems Biology

Tobias Bollenbach

Cells need to respond to a variety of signals in their environment, such as nutrients, drugs and signaling molecules. The Bollenbach group studies how cellular responses are computed and integrated, particularly in environments that contain multiple, potentially conflicting, signals. The experimental system the group currently focuses on is the bacterial response to antibiotics underlies suppressive drug interactions. The Bollenbach group combines quantitative experiments with statistical data analysis and theoretical modeling approaches to identify general design principles of cellular gene regulation responses. Using these quantitative approaches, the group aims to find new strategies of combining the currently available drugs in ways that maximize their efficiency while minimizing the evolution of drug resistance.

Current Projects
- Cellular responses to conflicting signals
- Mechanisms of drug interactions
- Physical descriptions of animal development

SELECTED PUBLICATIONS
- *equal contribution

TEAM
- Victoria Beerbaum (Postdoc), Guilherme Gomes (Postdoc), Maria Dravicek (PhD student), Jiri de Vos (Postdoc), Karin Mikesch (PhD student), Julia Tischler (Postdoc), Marcel Zagni (Postdoc)
Game theory, the study of interactive decision problems, can be used to study problems in logic and set theory, economics, cell, population and evolutionary biology, and the design of the internet. The Chatterjee group is interested in the theoretical foundations of game theory and formal verification. Game theory in the formal verification of software involves the study of interactive decision problems, which can be used to model and analyze the behavior of computer systems. The Chatterjee group works on theoretical aspects for the formal verification of systems, including the development of algorithms and verification techniques.

**Current Projects**
- Quantitative verification
- Stochastic game theory
- Modern graph algorithms for verification problems
- Evolutionary game theory
Transforming novel information to memory is essential if we want to remember it again later. Memory formation is therefore crucial for learning new facts or skills. The Csicsvari group studies how learning is implemented in the brain.

During learning, memory traces are processed and encoded in neuronal circuits and consolidated for later recall. The Csicsvari group focuses on the hippocampus, a brain area known to be important for spatial memory formation, and aims to understand how learning leads to memory formation. The group seeks to understand how neuronal circuits process information and form spatial memory by recording the activity of many neurons in different brain circuits during learning tasks and sleep. In addition, optogenetic methods are used to selectively manipulate neurons in different brain circuits during learning tasks and sleep. In addition, optogenetic methods are used to selectively manipulate neuronal activity in the hippocampus. Different place learning tasks allow the researchers to investigate the role of oscillatory activity during encoding, consolidation and recall of spatial information. To store spatial memory, the hippocampus interacts with other cortical regions, and the Csicsvari group investigates whether and how synchronous oscillations between the hippocampus and the entorhinal cortex are required for learning new facts or skills. The Csicsvari group investigates whether and how synchronous oscillations between the hippocampus and the entorhinal cortex are required for learning new facts or skills. The Csicsvari group investigates whether and how synchronous oscillations between the hippocampus and the entorhinal cortex are required for learning new facts or skills.

Current Projects
- Oscillatory interactions in working memory
- Role of hippocampal formation in spatial learning
- Activation of brain structures using light sensitive channels to study memory formation

Algorithms, Computational Geometry & Topology

Uncovering fundamental shapes in a sea of occurrences is a central task in Computational Geometry and Topology. The Edelsbrunner group drives the frontiers in this constantly reshaping field of science.

Topology, the study of shapes and how they are connected and deform, can be used to address a number of questions in applications as diverse as dynamical systems, scientific visualization, structural molecular biology, systems biology, geometry processing, medical imaging and orthodontics. The common theme in these applications is the importance of recognizing connections and their dependence on scale. The question of scale and how reality changes as we zoom in and out is particularly fascinating. The Edelsbrunner group studies the two related subjects of topology and geometry from a computational point of view, in order to make mathematical insights useful in applications that are workable for nonspecialists. The group believes in a broad approach to problems, including the development of new mathematics, the translation into new computational methods, and the application to frontiers of science. Some candidate areas for fruitful collaborations are cell biology, neuroscience, medical imaging, and astronomy.

Current Projects
- Discrete and computational geometry
- Applied computational algebraic topology
- Topological dynamical systems
While animals can move away if conditions turn harsh, plants are rooted in their environment. Plants so have become remarkably adaptable to different conditions. The Friml group investigates the mechanisms underlying their adaptability during plants’ embryonic and postembryonic development.

Plants and animals live different lives. While animals can react to conditions by changing their behavior, plants have acquired a highly adaptive development that allows them to respond to changes. In development, plants can do much more than animals, such as growing new organs.

Many of plants unique developmental events are mediated by auxin, a plant hormone. The Friml group investigates the unique properties of auxin signaling, standing out among plant signaling molecules due to the integration of both environmental and endogenous signals in its gradients within plant tissues. Employing methods spanning physiology, developmental and cell biology, genetics, biochemistry and mathematical modeling, the group focuses on polar auxin transport, cell polarity, endocytosis and recycling, as well as non-transcriptional mechanisms of signaling. In their work, the Friml group obtains fundamental insights into the mechanisms governing plant development. They show how signals from the environment are integrated into plant signaling and result in changes to plant growth and development. Many of their results are relevant for agriculture, providing a conceptual possibility for altering developmental processes.

Current Projects
- Polar auxin transport
- Cell polarity and polar targeting
- Endocytosis and recycling

SELECTED PUBLICATIONS
Networking is important on any level and in any environment – even in bacteria, genes and proteins are networking. But which basic rules, if any, do these networks follow? Using systems and synthetic biology, the Guet group explores the biology of genetic networks by analyzing both natural and synthetic networks.

Genes and proteins constitute themselves into bio-molecular networks in cells. These genetic networks are engaged in a constant process of decision-making and computation over time scales of a few seconds to the time it takes the organism to replicate, and even beyond. By studying existing networks and constructing synthetic networks in living cells, the Guet group aims to uncover the existence of universal rules that govern bio-molecular networks. The group uses the bacterium Escherichia coli as a model system due to its relative simplicity and the powerful experimental genetic tools available. One aspect of the Guet group's work comes in two flavors: (1) analyzing the biology of genetic networks by investigating both natural and synthetic networks. The most elaborate shapes of multicellular organisms – the elephant's trunk, the orchid blossom, the lobster's claw – all start off from a single bunch of cells. This transformation of a seemingly unstructured cluster of cells into highly elaborate shapes is a common and fundamental principle in cell and developmental biology and the focus of the Heisenberg group's work.

The group has chosen a multidisciplinary approach to analyzing gastrulation in zebrafish. Gastrulation is a highly conserved process in which a seemingly unstructured cluster of cells is transformed into a highly organized embryo. In zebrafish, this process occurs during a rapid period in development called the blastula stage. The blastula stage is characterized by the formation of three germ layers, which ultimately develop into different tissues and organs. Insights derived from this work may ultimately have implications for the study of wound healing and cancer biology, as immune and cancer cells share many morphogenetic properties of embryonic cells.

**Current Projects**
- Cell adhesion
- Actomyosin contractility and morphogenesis
- Cell polarization and migration

The Heisenberg group studies the molecular and cellular mechanisms by which vertebrate embryos take shape. To gain insights into critical processes in morphogenesis, the group focuses on gastrulation movements in zebrafish. Gastrulation is a highly conserved process in which a seemingly unstructured blastula is transformed into a highly organized embryo. The group has chosen a multidisciplinary approach to analyzing gastrulation, employing a combination of genetic, cell biological, biochemical and biophysical techniques. Using these tools, the group is deciphering key effector mechanisms involved in giving vertebrate embryos shape, such as cell adhesion and aggregation, cell polarization and cell migration. One central question they address is how adhesion between cells influences the specification and sorting of different populations of cells, which ultimately develop into different tissues and organs. Insights derived from this work may ultimately have implications for the study of wound healing and cancer biology, as immune and cancer cells share many morphogenetic properties of embryonic cells.

**Team**
- Anna Anderson (Joint Postdoc), Tobias Bergmüller (Postdoc), Remy Chait (Postdoc), Tatjana Petrov (Joint Postdoc with Anna Andersson), Tobias Bergmiller (Technician), Verena Ruprecht (Joint Postdoc with Sixt Group).
- Vanessa Barone (PhD student), Martin Behrndt (PhD student), Daniel Cepak (PhD student), Julián Compagno (Postdoc), Gabby Kreis (Postdoc), Hoshi Mota (Postdoc), Kornelia Pranic-Ferscha (Technician), Verena Ruprecht (Joint Postdoc with Sixt Group), Kseniya Savelieva (Postdoc), Philipp Schmalhorst (Postdoc), Malwina Sikora (Postdoc), Jana Slováková (Postdoc), Michael Smutny (Postdoc).
Humans and computers are surprisingly similar: while the interaction between two actors may be simple, every additional actor complicates matters. The Henzinger group builds the mathematical foundations for designing complex hardware and software systems.

Over 90% of today’s worldwide computing power is found in unexpected places like cell phones, kitchen appliances, and pacemakers. Software has become one of the most complicated artifacts produced by man, making software bugs unavoidable. The Henzinger group addresses the challenge of reducing software bugs in concurrent and embedded systems. Concurrent systems consist of parallel processes that interact with one another, whether in a global network or on a tiny chip. Because of the large number of possible interactions between parallel processes, concurrent software is particularly error-prone, and sometimes bugs appear only after years of flawless operation. Embedded systems interact with the physical world; an additional challenge for this kind of safety-critical software is to react sufficiently fast. The Henzinger group invents mathematical methods and develops computational tools for improving critical software.

Current Projects
- Predictability and robustness for real-time and embedded systems
- Analysis and synthesis of concurrent software
- Quantitative modeling and verification of reactive systems
- Precise verification of concurrent software
- Model checking biochemical reaction networks
- Building tools and techniques for concurrent software
- Human and computer interactions

Selected Distinctions
- Highly Cited Researcher
- Adobe Fellow
- Willettawan Award
- Honorary Doctorate, University Joseph Fourier, Grenoble, France
- Logic in Computer Science Test-of-Time Award
- Member, Austrian Academy of Sciences
- ACM SIGSOFT Impact Paper Award
- ERC Advanced Grant
- ACM Fellow
- IEEE Fellow
- Member, Academia Europaea
- German Academy of Sciences Leopoldina Young Investigation Award
- NSF Faculty Early Career Development Award
- Automatic Inevitability Proofs of Concurrent Objects with Cooperating Updates, Proc. Conf. Computer-Aided Verification (CAV), Lecture Notes in Computer Science
- Henzinger, T., Malikova, M. 2013. The propagation approach for computing biochemical reaction networks, IEEE-ACM Transactions on Computational Biology and Bioinformatics

Team
- Udi Baker (Postdoc), Prazmowska Daca (PhD student), Cezara Dragoi (Postdoc), Ankush Goel (Postdoc), Jon Kutek (Joint Postdoc with Chatterjee group), Jan Otop (Postdoc), Ajoy Rashkhisina (PhD student), Ali Saeigh (Postdoc), Thorsten Tarnow (PhD student), Damien Zufferey (PhD student)
**Nonlinear Dynamics and Turbulence**

**Björn Hof**

Turbulent flow in water and other liquids is the most prominently encountered form of disorder in nature. The Hof group seeks insights into the fundamental nature of turbulence, and the dynamics of complex fluids.

Weather systems, galaxy and planet formation, airflow and networks are governed by complex chaotic dynamics. Fluid turbulence—seen in liquids such as water or oil—is the most common form of disorder in nature. Devised to emanate from smooth, laminar flow. The group combines detailed laboratory experiments with highly resolved computer simulations, and applies methods from nonlinear dynamics and statistical physics.

The group actively develops such methods. The group’s insights can be directly applied to control turbulent flow, and the researchers to switch it on or off. This optogenetic approach is used as a “remote control” to activate or inactivate the receptor, allowing the researchers to switch it on or off. This optogenetic approach is used to study circuits and networks by activating or inactivating them at any given point, and allows researchers to analyze information processing in the brain and during signaling processes in general.

**Current Projects:**
- Transition from laminar to turbulent flow
- Dynamics of complex fluids

**SELECTED PUBLICATIONS**

**SELECTED DISTINCTIONS**
- 2011 ERC Starting Grant (consolidator)
- 2011 Dr. Meyer Struckmann Science Prize
- 2012 RCUK Fellowship

**CAREER**
- Since 2013 Professor, IST Austria
- 2007-2013 Max Planck Research Group Leader, Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany
- 2005-2007 Lecturer, University of Manchester, Manchester, UK
- 2003-2005 Research Associate, Delft University of Technology, Duth, The Netherlands
- 2001 PhD, University of Manchester, Manchester, UK

**TEAM**
- Sebastian Altmejer (Postdoc), Jose Manuel Galiardo Ruiz (Postdoc), Shivayak Vaman Jakkal (Postdoc), Jako Kühnen (Postdoc), Gregoire Lemoult (Postdoc), Philipp Maier (Technician), Liang Shi (PhD student), Shreyas Vaman Jalikop (Postdoc), Jakob Kühnen (Postdoc), Gregoire Lemoult (Postdoc)
- Pedro de Lazzari (Technician), Baofang Song (PhD student), Mukund Vasudevan (Postdoc)
- Sebastian Altmejer (Postdoc), Jose Manuel Galiardo Ruiz (Postdoc), Shivayak Vaman Jakkal (Postdoc), Jako Kühnen (Postdoc), Gregoire Lemoult (Postdoc), Philipp Maier (Technician), Liang Shi (PhD student), Shreyas Vaman Jalikop (Postdoc), Jakob Kühnen (Postdoc), Gregoire Lemoult (Postdoc)

**Synthetic Physiology**

**Harald Janovjak**

When first faced with a new machine, an engineer’s instinct is to disassemble it to understand its inner workings. The Janovjak group uses optogenetics to take apart the cell’s signaling machinery and gain a better insight into how it orchestrates virtually all cellular functions.

Receptors on the cell surface are the antennas that receive signals and pass them on to the inside of the cell, causing specific and tightly controlled responses. The Janovjak group seeks to understand this process and takes a unique biophysical approach to actively manipulate signaling pathways. In multiple experimental systems, receptors are engineered to respond to a light stimulus rather than to the native signal. Light is then used as a “remote control” to activate or inactivate the receptor, allowing the researchers to switch it on or off. This optogenetic approach is used to study circuits and networks by activating or inactivating them at any given point, and allows researchers to analyze information processing in the brain and during signaling processes in general.

**Current Projects:**
- Optogenetic identification of active signaling pathways
- Manipulation of sensory domains to study receptor dimerization
- Theoretical models of receptor activation

**SELECTED PUBLICATIONS**

**TEAM**
- Alvaro Ingles Prieto (Postdoc), Catherine Möckleisen (PhD student), Maurizio Morri (PhD student), Robert Feider (Student Intern), Inmaculada Sanchez Romero (Postdoc), Miroslava Spanova (Technician)
Synaptic Communication in Hippocampal Microcircuits

Peter Jonas

Synapses enable communication between neurons in the brain. The Jonas group investigates how signals pass through these vital interfaces—a major undertaking in the field of neuroscience.

Understanding the function of neuronal microcircuits is one of the major challenges of life science in the 21st century. The human brain is composed of approximately 10 billion neurons, which communicate with each other at a huge number of synapses, specialized sites of contact between neurons. Broadly, synapses in the brain fall into two categories: excitatory and inhibitory. Excitatory synapses transmit signals that increase the likelihood of a neuron firing, while inhibitory synapses transmit signals that decrease the likelihood of a neuron firing. The Jonas group aims to obtain a quantitative nanophysiological picture of signaling in this type of interneuron. This research has far-reaching implications for understanding the contribution of GABAergic interneurons to neuronal coding and brain energetics, and may lay the basis for the development of new therapeutic strategies against diseases of the nervous system.

Current Projects
- Nanophysiology of fast-spiking, parvalbumin-expressing GABAergic interneurons
- Analysis of synaptic mechanisms of information storage
- Analysis of hippocampal synaptic transmission in vivo

Synaptic Communication in 34 IST Austria Annual Report 2013

The Jonas group examines subcellular electrophysiological recording, subcellular patch-clamp techniques, Ca²⁺ imaging, and modeling. Amongst other projects, the group examines subcellular elements of the fast-spiking, parvalbumin-expressing GABAergic interneurons in the hippocampus, which are thought to contribute to storage and retrieval of memories. These interneurons play a key role in cortical neuronal networks, and the Jonas group aims to obtain a quantitative nanophysiological picture of signaling in this type of interneuron. This research has far-reaching implications for understanding the contribution of GABAergic interneurons to neuronal coding and brain energetics, and may lay the basis for the development of new therapeutic strategies against diseases of the nervous system.

Computer Vision and Discrete Optimization Algorithms

Vladimir Kolmogorov

Stepping out on the street, we automatically judge the distance and speed of cars. For computers, estimating the depth of objects in an image requires complex computation. The Kolmogorov group’s work on algorithms gives computers “stereo vision”.

Research of Vladimir Kolmogorov’s group focuses on the development of efficient algorithms for inference in graphical models, which have applications in many different fields such as computer vision, computer graphics, data mining, machine learning, and bioinformatics. Two classical examples from computer vision are binary image segmentation and stereo vision problems. Binary image segmentation gives automatic systems the ability to divide an image into foreground and background, while stereo vision allows them to infer the depth of objects. Kolmogorov has developed algorithms widely used in computer vision, such as the “Boykov-Kolmogorov” maximum flow algorithm and the “TRW-S” algorithm for inference in graphical models. His “Blossom V” algorithm is currently the fastest technique for computing a minimum cost perfect matching in a graph. Vladimir Kolmogorov has also done theoretical work on the analysis of discrete optimization problems.

Current Projects
- Inference in graphical models
- Combinatorial optimization problems
- Theory of discrete optimization

SELECTED PUBLICATIONS
- Gridchyn I, Kolmogorov V. 2013. “Potts model, parametric min-cut and K-submodular functions”. In IEEE International Conference on Computer Vision (ICCV), Sydney, Australia.
- Rustem Talakan (Postdoc)
Computer Vision and Machine Learning

Christoph Lampert

Every kid knows how to play “I spy with my little eye”, but to a computer the task of analyzing images and recognizing objects is tremendously difficult. The Lampert group helps computers “see” with the tools of machine learning essential for applications requiring computer vision.

Recognizing objects in an image is child’s play to humans, but presents an exceedingly difficult challenge to computers. The Lampert group develops algorithms that allow computers to analyze high-dimensional data and make decisions based on it. In machine learning, computers arrive at knowing general rules by making abstractions based on examples provided. Object recognition is one aspect of machine learning essential for applications requiring computer vision.

In their research, the Lampert group develops algorithms that enable automatic image understanding systems to analyze digital images regarding their contents. In the long run, the Lampert group is interested in building automatic systems that understand images on the same semantic level as humans do, enabling them to answer questions like: What objects are visible in an image? Where are they located? How do they interact?

Current Projects
- Life-long learning for visual scene understanding
- Object recognition and localization
- Structured prediction and learning
- Attribute representations

Light-weight devices require simple and efficient cryptographic schemes.

Cryptography

Krzysztof Pietrzak

Cryptography, the science of information security, is often relegated to the realm of spies and agents. However, we all rely on cryptography on a daily basis, for example when using internet banking or a wireless car key.

The Pietrzak group works on theoretical and practical aspects of cryptography. One focus of their work is the construction of provably secure cryptographic schemes for light-weight devices such as RFID tags, which are used in many security-relevant applications like electronic passports or for access control. RFID tags are typically too constrained to run existing cryptographic schemes, and thus one must design schemes that are provably secure, but at the same time extremely simple and efficient.

Another line of work is concerned with so called “side-channel attacks”. These are attacks on cryptographic devices, for example smart-cards, in which one measures information leaked during computation, and then exploits it to break the security of the scheme. This information can for example be the power consumption or emitted radiation. The group works on “leakage-resilient cryptography”, which aims at constructing schemes which remain provably secure even in the context of side-channel attacks.

Current Projects
- Leakage-resilient cryptography
- Cryptosystems for light-weight devices
- Computational Entropy

TEAM

SELECTED PUBLICATIONS

SELECTED DISTINCTIONS
- 2012 ERC Starting Grant
- 2008 Best Paper Award, IEEE Conference for Computer Vision and Pattern Recognition (CVPR)
- 2008 Best Student Paper Award, European Conference for Computer Vision (ECCV)
- 2008 Max Planck, German Society for Pattern Recognition (DAGM)

SELECTED PUBLICATIONS

SELECTED DISTINCTIONS
- 2012 ERC Starting Grant
- 2008 Best Paper Award, IEEE Conference for Computer Vision and Pattern Recognition (CVPR)
- 2008 Best Student Paper Award, European Conference for Computer Vision (ECCV)
- 2008 Max Planck, German Society for Pattern Recognition (DAGM)

SELECTED PUBLICATIONS

SELECTED DISTINCTIONS
- 2012 ERC Starting Grant
- 2008 Best Paper Award, IEEE Conference for Computer Vision and Pattern Recognition (CVPR)
- 2008 Best Student Paper Award, European Conference for Computer Vision (ECCV)
- 2008 Max Planck, German Society for Pattern Recognition (DAGM)

SELECTED PUBLICATIONS
Robert Seiringer

Many-body systems in quantum mechanics display a rich variety of complex phenomena. The Seiringer group develops new mathematical tools in the quest to seek a thorough understanding of their basic underlying principles.

Ice and water may look different, but are in fact described by the same equations of quantum mechanics. How the same equations can lead to different behaviors depends on the properties of the system, such as temperature and pressure. The Seiringer group focuses on many-body systems in quantum mechanics, in particular on problems in quantum statistical mechanics and condensed matter physics. They investigate how atoms and molecules, the building blocks of matter, interact and how this interplay of fundamental parts affects the entire system, and mathematically analyze the behavior of condensed matter at very low temperatures. The Seiringer group applies modern mathematical techniques and even develops new mathematical tools for the rigorous analysis of physical systems.

Current Projects

- The Heisenberg ferromagnet at low temperature and the spin-wave approximation
- Structure and dynamics of polarons at strong coupling
- Excitation spectrum and superfluidity for weakly interacting Bose gases

Selected Distinctions

- 2012-2017 William Davidson Scholarship
- 2013-2014 NSERC E.U.R. Excellence Memorial Fellowship
- 2009-2010 U.S. National Science Foundation CAREER grant
- 2009 Henri Poincare Prize of the International Association of Mathematicians Physics
- 2004-2005 Alfred P. Sloan Research Fellowship
- 2001-2003 Erwin Schrödinger Fellow

Selected Publications


TEAM

- Phan Thanh Nam (Postdoc), Jimena Royo-Letelier (Postdoc)

Ryuichi Shigemoto

Information transmission, the formation of memory and plasticity are all controlled by various molecules at work in the brain. Focusing on the localization and distribution of molecules in brain cells, the Shigemoto group investigates their functional roles in higher brain functions.

The release of neurotransmitters from a nerve cell into the synapse, where they act on receptors on the connecting nerve cell, is the primary way of information transmission and computation in the brain. The Shigemoto group studies the localization of single neurotransmitter receptors, ion channels and other functional molecules to understand the molecular basis of neuronal computation. The group has pioneered several methods for studying the localization of functional molecules at an unprecedented level of detail and sensitivity, detecting and visualizing even single membrane proteins in nerve cells using SDS-digested freeze fracture replica labeling. They apply these methods to investigate the mechanisms of signaling and plasticity in the brain, with questions ranging from neurotransmission to learning. The Shigemoto group studies the molecular mechanisms for long-term memory formation and stabilization, focusing on motor and spatial learning and emotional memory formation, mediated by structural changes in brain regions. They are also working on the left-right asymmetry of synaptic connections, receptor allocations and behaviors, to clarify both its physiological significance and the mechanism of asymmetry formation. The laterality of brain function is well known in humans, but the molecular determinants of this laterality are still largely elusive.

Current Projects

- Ultrastructural localization and function of receptors and ion channels in the brain
- Mechanisms of long-term memory formation
- Left-right asymmetry of hippocampal circuitry

Selected Distinctions

- 2008-2010 U.S. National Science Foundation CAREER grant
- 2009-2010 U.S. National Science Foundation CAREER grant
- 2009-2010 U.S. National Science Foundation CAREER grant
- 2009 Henri Poincare Prize of the International Association of Mathematicians Physics
- 2004-2005 Alfred P. Sloan Research Fellowship
- 2001-2003 Erwin Schrödinger Fellow

Selected Publications


TEAM

- Pradeep Bhandari (PhD student), Matthew Julian Case (PhD student), Harumi Harada (Postdoc), Seibun Kasai (PhD student)
Cells actively move to get around the body. Cells’ ability to migrate is crucial for their function in the immune system, formation of the body and the spread of cancer. The Siekhaus group investigates how cells move in the complex environment of an organism.

Cells, the building blocks of life, mostly remain stationary to form stable organs and tissues. However, some of our cells need to migrate through our body, as they fight infecting pathogens. The group of Daria Siekhaus studies how these immune cells move during the development of the fruit fly Drosophila melanogaster from the place they are born to their final locations in the embryo. The Siekhaus group has shown that one particular developmental path taken by the immune cells requires them to squeeze through a tissue barrier. This behavior displays similarities with that of vertebrate immune cells that use the vasculature as a highway for easy migration through the body, and therefore need to squeeze through the wall of the blood vessels to enter and leave the vasculature. The Siekhaus group has identified many genes required for cells to overcome such barriers, and has shown that some of them allow cells to change shape and become “sticky” cells are. Using a powerful combination of imaging, genetics, cell biology and biophysics, the Siekhaus group seeks to understand the functions of these genes, the pathways they act in, and the strategies and principles that underlie invasive migration. Similar barrier penetration is involved in the metastatic spread of cancer cells, and the results of the Siekhaus group’s Drosophila studies may be translated to autoimmunity involved in the metastatic spread of cancer cells, and the results of the Siekhaus group’s Drosophila studies may be translated to autoimmunity.

Current Projects
- Understanding the communication between hemocytes and the barriers that they move through
- Understanding the regulation of adhesion that occurs during hemocyte migration

SELECTED PUBLICATIONS

TEAM
- Aparna Ratheesh (Postdoc), Vera Belyaeva (PhD student), Katarina Hribikova (PhD student), Altha Gyorgy (Technician)

SELECTED DISTINCTIONS
- 2012 Marie Curie Career Integration Grant
- 2003–2005 NIH Fellowship
- 2001-2002 NRSA Fellowship

SELECTED PUBLICATIONS
Networks that process and transmit information are everywhere in biology. Neurons, signaling molecules, genes, and organisms are part of extensive networks that have evolved to detect, represent, and compute responses to changes in the environment or the organism’s internal state. The Tkačik group uses theoretical biophysics to study information processing in such biological networks.

The Tkačik group focuses on information flow in biological networks, using tools from statistical physics of disordered systems and information theory to analyze, compare and model examples of biological computation. This biological computation takes place across a large range of time scales and is implemented using very different substrates, for instance electrical signals, transcription factor concentrations, covalent modification states of signaling molecules, or visual and auditory signals. The group looks for design principles that would predict how biological networks are wired to perform their functions well under biophysical noise and resource constraints. Their work spans the range from biophysics, signal transduction and genetic regulation over computational neuroscience to the collective motion of groups of organisms.

Current Projects
- Visual encoding in the retina
- Genetic regulation during early embryogenesis
- Collective dynamics in groups of organisms

SELECTED PUBLICATIONS

SELECTED DISTINCTIONS
- 2012: HFSP grant
- 2006: Charlotte E Procter Honorary Fellowship, Princeton University
- 2003: Burroughs-Wellcome Fellowship, Princeton University
- 2002: Golden sign of the University of Louisiana

TEA M
- Anna Andersson (Postdoc), Karatina Badova (Postdoc), Vicente Botella Soler (Postdoc), Tamal Freidlandner (Postdoc / IST Fellow, joint with Barton and Gueli groups), Gabriel Mitchell (Postdoc), Cristina Savin (Postdoc / IST Fellow), Georg Nolte (PhD student)

SELECTED PUBLICATIONS

How are chromosomes packed into the cell’s nucleus? How many observations are minimally needed for estimating interactions between genes? How can privacy be ensured when releasing genomic data? The Uhler group works on algebraic statistics and addresses questions in computational biology.

Algebraic statistics exploits the use of algebraic techniques to study statistical problems, and to develop new paradigms and algorithms for data analysis and statistical inference. Algebraic methods have proven to be useful for statistical theory and applications alike. As such, the work of the Uhler group is at the interface of mathematical modeling, statistics and computational biology. On the theoretical side, the Uhler group works on gaining a better understanding of the mathematics and geometry of graphical models with hidden variables, particularly for causal inference. Another research direction consists of developing methods for model selection in random graph models. Projects motivated by biological problems include the understanding of the spatial organization of chromosomes inside the cell’s nucleus. Gene expression is, amongst others, dependent on the proximity of different chromosomes and chromosomal regions. The Uhler group studies the organization of the mammalian genome under a probabilistic model, a fascinating problem at the interface of computational biology, statistics, optimization and computational geometry. Other questions addressed include the development of methods to release data from genomewide association studies without compromising an individual’s privacy.

Current Projects
- Causal inference
- Graphical models with hidden variables
- Model selection in random graph models
- Chromosome packing in cell nuclei
- Privacy preserving data sharing for genomic data

SELECTED DISTINCTIONS
- 2012–2011: Janggen-Poehn Fellowship
- 2007–2010: International Fulbright Science and Technology Award
- 2006: Best Student Award of the University of Zürich

TEAM
- Caroline Uhler (Postdoc), Katia Efstathiou (Postdoc), Milena Minc (PhD student, joint with Edelsbrunner group), Anna Klimova (Postdoc), Patrik Novin (Postdoc)
Combinatorics, Geometry and Topology

Uli Wagner

How are molecules connected through chemical bonds? How do people know each other? How is a city’s road network laid out? All these are questions on connections – of objects, places or people. Asking questions about connections mathematically, the Wagner group’s focus lies on combinatorial and computational geometry and topology.

Graphs consist of vertices – points such as houses – and edges which connect vertices – for example connecting roads. Classical graph theory then asks questions on these graphs: is a graph planar, so can all points be connected without the connections crossing each other? What does the fact that a graph is planar tell us about the connections, e.g. about a city’s road map? Such graphs are one-dimensional shapes. The Wagner group studies questions analogous to these classical questions of graph theory for geometric shapes and structures of higher dimensions. They ask whether a shape can be fitted in higher dimensional space, and what information this conveys about the shape’s structure and complexity.

The realistic simulation of complex processes in the physical world is the focus of research in the Wojtan group. Using numerical techniques, they create computer simulations of physical phenomena such as fluids, deformable bodies or cloth. Such accurate representations are required not only for computer animation, but also for medical simulations, computational physics and digital modeling. In their work, the Wojtan group combines mathematical methods from computational physics with geometric techniques from computer graphics. A key contribution of the Wojtan group is the efficient treatment of topological changes with deforming meshes that split and merge, in order to simulate highly detailed surface tension phenomena, such as the formation of water droplets and splashes.

Deceptively realistic virtual worlds, animated movies and computer games are highly popular. Complex calculations and models operate in the background to achieve these accurate simulations. The Wojtan group uses numerical techniques to provide the basis for complex animations and graphics.

Current Projects
- Simulating fractured materials to create highly detailed surfaces
- Generating temporally coherent deforming surfaces with changing topology from space-time data
- Efficient simulation of fluid dynamics

SELECTED PUBLICATIONS
New Professors

Mikhail Lemeshko

Mikhail Lemeshko studies complex physics phenomena using controllable quantum systems. Lemeshko studied Physics at the Southern Federal University in Rostov-on-Don, Russia. He obtained his PhD in 2011, having worked in the group of Breitländer Friedrich in the Department of Molecular Physics at the Fritz Haber Institute of the Max Planck Society in Berlin. In his doctoral research, Lemeshko focused on the manipulation of molecules and their interactions with external fields, with one of the main results being the deformation behavior of soft tissue, animals and empty spaces. Lemeshko is interested in using tools of atomic physics to answer questions arising in condensed matter physics and, from an equilibrium of behavior of open quantum systems. Mikhail Lemeshko joins IST Austria as Assistant Professor in 2014.

Gaia Novarino

Gaia Novarino investigates the genetic and molecular basis of epilepsy and cognitive disorders. Novarino studied Molecular Biology and received her PhD in Cell Biology in 2006 at Sapienza University in Rome, Italy, having performed her pre-doctoral studies at “La Sapienza”, at the Vanderbilt University Medical Center in Nashville, Tennessee and at the Center for Molecular Neurobiology in Hamburg. Novarino spent four years as postdoctoral fellow at the Max-Planck Center for Molecular Medicine in Berlin before moving to the laboratory of Joseph Gleeson at the University of California San Diego in November 2010. A core interest of Novarino’s research are the molecular functions of genes underlying epilepsy, autism and intellectual disabilities in humans. This research program is based on the combination of the new generation of DNA sequencing techniques with cell and molecular biology and animal modeling. Gaia Novarino joins IST Austria as Assistant Professor in 2014.

Bernd Bickel

Bernd Bickel is interested in computer graphics and its applications in animation, biomechanics, material science and computational design for digital fabrication. Bickel studied Computer Science at ETH Zurich, where he also received his PhD in 2010, having performed research in the Computer Graphics Laboratory under the supervision of Markus Gross. Following his PhD, Bickel joined Disney Research Zurich as Postdoc, and was appointed as Visiting Professor at TU Berlin from 2011 to 2012. Since 2012, Bickel is a researcher and research group leader at Disney Research Zurich. Bickel’s recent work includes next generation 3D surface scanner devices, performance capture, measuring and modeling the deformation behavior of soft tissue, animation tools, and computational synthesis for 3D printing. Bernd Bickel will join IST Austria as Assistant Professor in 2015.

Grants & Prizes

International grants

The most prestigious grants for basic research on the European level are awarded by the European Research Council (ERC). Established in 2007 by the European Union, the ERC is the first pan-European funding organization for frontier research. It aims to stimulate scientific excellence in Europe by encouraging competition for funding between the very best researchers of any nationality. In 2013, two faculty members of IST Austria received ERC grants. The mathematician Laszlo Erdős received an ERC Advanced Investigator Grant, while the computer scientist Vladimir Kolmogorov received an ERC Consolidator Grant, bringing the total number of ERC grants among the IST Austria faculty to 14. Erdős obtained the grant for his work on the mathematics of disordered quantum systems and matrices. In the ERC-funded project, he will tackle the universality of random matrix theory. Kolmogorov received the ERC grant for his project on “Discrete Optimization in Computer Vision”, which will allow him to focus on so-called MAP estimation algorithms. These algorithms have revolutionized the field of computer vision in the past decade and are now commonly used also in commercial products.

The Human Frontier Science Program (HFSP), a global funding agency, competitively selects cutting-edge, risky projects that are pursued by international, interdisciplinary teams. In 2013, a prestigious HFSP grant was awarded to an international team that includes IST Austria professor Tobias Bollenbach and performs research on the limits of cell growth. This brings the total number of HFSP projects at IST Austria to five.

National awards

The scientists of IST Austria were also honored through national awards and prizes. For his exceptional contributions in the field of evolutionary population genetics, Nick Barton also received this year’s Erwin Schrödinger Prize of the Austrian Academy of Sciences. The Erwin Schrödinger Prize is awarded each year to a scientist working in Austria with outstanding scientific achievements. Also the postdocs and students of IST Austria received several prizes recognizing their research. One such prize went to mathematician Hildegard Uecker, postdoc in the group of Nick Barton, who received the Carl-Dieter-Award of the German Mathematical Society for his research on the social immune system of ants.

Hansgeorg Schindler Young Investigator Award supported by the Austrian National Bank. The award is aimed at excellent young female scientists and will support Uecker’s research on the circumstances under which a population endangered with extinction can ensure its continued survival by genetic adaption to the new environment.

Other early-stage researchers who received recognition this year include Matusz Sikora, who received an EMBO long-term fellowship to support his postdoctoral studies in the group of Carl-Philip Heisenberg, and Martin Berendt, also of the Heisenberg group, who received the Hansgeorg Schindler Young Investigator Award by Biophysics Austria.
Research grants and awards (selection)

- ERC Starting Grant – Nick Barton
- HFN Grant – Tobias Bollenbach
- Microsoft Research Faculty Fellowship – Krishnendu Chatterjee
- HFSP Grants – Tobias Bollenbach, Călin Guet, Harald Janovjak, Michael Sixt, Gašper Tkačik
- Mega Grant by the Russian Government – Herbert Edelsbrunner
- EU Research grants and awards
  - Topological Complex Systems, FP7-Cooperation, €498'000, 04/2011-03/2014
  - Social Vaccines - Social Vaccination in Ant Colonies: from Infection, Programmability and Collective disease defence and pathogen detection abilities
  - Molecules and Microorganisms for Synthetic Neurobiology, MC-CIG, €12'000, 09/2013-05/2014
  - Mechanisms of transmitter release at GABAergic synapses, ERC Consolidator Grant, €1'397'000, 06/2013-12/2017
  - Random matrices, universality and disordered quantum systems, ERC Advanced Grant, €1'755'000, 03/2014-02/2019

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- Chatterjee K, Henzinger TA. From verification to synthesis: From unlocking the black box of systems to leverage learning and adaptive system design. Proc. of VLSI Design 2013, 181-196.
- Chatterjee K, Henzinger TA. From verification to synthesis: From unlocking the black box of systems to leverage learning and adaptive system design. Proc. of CSL 2013, 18-25.
- Chatterjee K, Henzinger TA. From verification to synthesis: From unlocking the black box of systems to leverage learning and adaptive system design. Proc. of SARC 2013, 181-196.
- Chatterjee K, Henzinger TA. From verification to synthesis: From unlocking the black box of systems to leverage learning and adaptive system design. Proc. of VLSI Design 2013, 181-196.
Bendich P, Edelsbrunner H, Morozov D, Patel A. Homology
Dupret D, O’Neill J, Csicsvari J. Dynamic reconfiguration of
Tragust S, Ugelvig LV, Chapuisat M, Heinze J, Cremer. Pu -
Cremer group

Chatterjee K, Randour M, Raskin JF. Strategy synthesis for

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mapping identify core regions of the rice genome control -
Experiments 2013, 70-77.

2670-2675.

and robustness of level and interlevel sets. Homology, Ho-

F, Save E. Distinct roles of medial and lateral entorhinal cor-

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Erdőss L, Knowles A, Yau H, Yin J. Spectral statistics of

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An integral part of scientific discovery and progress is sharing and discussing new findings. Scientific conferences, symposia, and seminars provide a platform for exchange. IST Austria is linked to the scientific community through a range of scientific events, from annual conferences to weekly seminars.

Conferences and symposia

In August, IST Austria hosted the 38th International Symposium on Mathematical Foundations of Computer Science (MFCS). The series of MFCS symposia, organized in rotation by the Czech Republic, Poland, and Slovakia since 1972, has a long and well-established tradition. The five-day symposium at IST Austria was the first MFCS symposium to be held outside the three countries. For IST Austria, it was the largest scientific event held on its campus so far. Another large conference took place in September: the 11th International Conference on Computation Models in Systems Biology (COSyBio) brought together computer scientists, biologists, mathematicians, engineers, and physicists interested in a system-level understanding of biological processes. It covered theory, computation as well as applications of the modelling and analysis of biological systems. In addition, several one-day symposia were held at IST Austria to exchange ideas, with topics ranging from ‘Frontiers of Solid State Research’ to ‘Quantum Information’. IST Austria was also host to scientific networking events, connecting researchers in the Vienna region and in Austria working on related topics, such as the Vienna Plant Network, the Neuroscience Vienna Network, and the Austrian Computer Science Day.

The IST Colloquium

An integral part of research activities are regular seminars on the latest developments in the scientific topics represented at the Institute. The IST Colloquium is IST Austria’s principal seminar series, to which leading international scientists from all disciplines of the natural, mathematical, and computer sciences are invited to present their latest findings. IST Colloquia have a strong administrative function; they bring together computer scientists, biologists, mathematicians, engineers, and physicists interested in a system-level understanding of biological processes. It covered theory, computation as well as applications of the modelling and analysis of biological systems. In addition, several one-day symposia were held at IST Austria to exchange ideas, with topics ranging from ‘Frontiers of Solid State Research’ to ‘Quantum Information’. IST Austria was also host to scientific networking events, connecting researchers in the Vienna region and in Austria working on related topics, such as the Vienna Plant Network, the Neuroscience Vienna Network, and the Austrian Computer Science Day.

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In the communication flow

IST Lectures
In the IST Lecture series, eminent scientists are invited to IST Austria to present their research and address topics of interest to the scientifically interested general public. In 2013, two distinguished scientists gave public IST Lectures at IST Austria. On April 24, the American mathematician Stephen Smale presented his work on the three-dimensional structures of proteins. On October 10, the biologist Bruce Levin shared his insights into the adaptive immune system of bacteria and its evolutionary dynamics.

Science-Industry Talk
The Science-Industry Talk series is a joint initiative of IST Austria and the Federation of Austrian Industries (IV). This year’s Science-Industry Talk on „Partners in Innovation: Synergies between Industry and Basic Research” offered a forum to discuss relations and exchanges between academia and industry with the aim of learning from the respective partners. The panel discussion included entrepreneur Horst Domdey, venture capitalist Hermann Hauser, TTTech founder Hermann Kopetz, and Assistant Managing Director of Microsoft Research India Sriram Rajamani.

Open Campus
The IST Austria campus was open to the public at the annual Open Campus. The friends and neighbors of IST Austria and their families were invited to spend the day at IST Austria and explore the day-to-day life of a research institution. Many hands-on science stations, such as cryptography workshops and fluid explorations, gave the visitors the opportunity to experience research for themselves. The Open Campus was rounded off with the award ceremony for the 2013 School Science Competition run by IST Austria, this year on the topic of „Forces in Nature”.

Science Slams
2013 marked a first for the participation of IST Austria scientists in Vienna Science Slams. Designed as a platform for researchers to talk about their work to a non-scientific public, the participants explain their research in simple terms in five minutes, with the audience judging who performed the best „slam”. Tom Ellis, PhD student in Nick Barton’s group, won the Vienna Science Slam on June 20 with an entertaining glimpse into his research on evolutionary dynamics using snapdragons. Leila el Masi, postdoc in the group of Sylvia Cremer, won the Science Slam held as part of the Vienna Science Festival on September 15, describing her work on ant immune systems.

IST Austria aims to increase the public awareness of basic research and actively seeks to reach out into the community. The Institute participates in many local and regional events, such as the Vienna Science Festival, and hosts many visits by different groups and constituencies.

Communicating science
Public funding, peer-reviewed research grants, private donations and, in the future, income from technology transfer set up a broad basis for the success of IST Austria. Private donations provide an essential pillar of support and IST Austria is profoundly grateful to the individuals and companies that have so generously contributed to research at the Institute.

In 2013, a new donor, Steven Heinz, together with existing donor OMV AG, supported the establishment of a scholarship program for new PhD students. Six students, who at the start of their scientific career show special promise, were chosen to be named Heinz and OMV scholars and began their doctoral studies at IST Austria’s graduate school in September 2013. In June, IST Austria inaugurated the Miba Machine Shop, named to honor the generous support of IST Austria by the technology company Miba AG. The Miba Machine Shop is a mechanical and electronic workshop for building experimental set-ups for our scientists.

In the future, IST Austria intends to use income from intellectual property rights to build a fourth pillar of financial support. The Institute is committed to promote the use of scientific discoveries through licensing and technology transfer. A technology park is planned adjacent to the IST Austria campus and a dedicated Technology Transfer Office takes care of all matters related to intellectual property developed at IST Austria.

## Cash flow

**Diverse Funds**

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<td>Boehringer Ingelheim International GmbH</td>
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<td>Alcatel-Lucent Austria AG</td>
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<td>Gebruder Weiss GmbH</td>
<td>Burkhard Stiller</td>
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<td>Kapsch AG</td>
<td>Ernst-Ludwig Winnacker</td>
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## Boards of IST Austria

### Executive Committee

- **Chair:** Claus J. Raidl, President, Oesterreichische Nationalbank, Vienna, Austria
- **Vice-Chair:** Angelika Amon, Professor, Department of Biology, MIT, Cambridge, USA
- **Secretary General:** Wolfgang Ruttnerstorfer, Chairman of the Supervisory Board, Vienna Insurance Group, Vienna, Austria

### Scientific Board

- **Chair:** Kurt Mehlhorn, Director, Max-Planck Institute for Informatics, Saarbrücken, Germany
- **Vice-Chair:** Olaf Kübler, Former President of ETH Zurich, Zurich, Switzerland
- **Institutes:**
  - Wolfgang Ruttnerstorfer, Chairman of the Supervisory Board, Vienna Insurance Group, Vienna, Austria
  - Gordon Plotkin, Professor, Laboratory for Foundations of Computer Science, University of Edinburgh, UK
  - Gregor Sch有很大贡献的组织和公司。
“Excellent service for excellent science. The goal of IST Austria’s administrative personnel is to provide excellent service to give scientists the ability to focus on their research. The growth of IST Austria also sets a challenge for the administration, which we are excited to take on. Several projects undertaken in 2013 to maintain top service standards in a growing research institute included a student life cycle software, expanded hospitality support, dual career service, and a new ordering platform. I thank all administrative employees for their excellent work and dedication in 2013.” — Georg Schneider, Managing Director, IST Austria
IST Austria is committed to the sharing of scientific resources among research groups wherever possible. To optimize cost efficiency and utilization, all shared resources are organized in central core facilities - Scientific Service Units (SSUs) – which support all scientists, students and staff of IST Austria by offering professional services, expertise and state-of-the-art equipment. The goal of the SSUs is to provide optimal conditions for cutting-edge research at an internationally competitive level. With the growth of IST Austria, the need for equipment and services provided by the SSUs is constantly expanding.

In 2013, the Electron Microscopy facility (EMF) was established to satisfy the need for ultra-structural analysis in the fields of neuroscience and cell biology. The EMF offers innovative state-of-the-art technologies, with one of the microscopes being the first of its kind in Europe. In addition, the expert personnel of the EMF support researchers with technically demanding procedures like sample preparation and image analysis.

To further support the theoretical disciplines on campus a dedicated new cluster offers computing capacity and storage for complex calculations and simulations.

With the move of the first experimental physics group to IST Austria, the Miba Machine Shop as well as the Life Science facility widened their services to now also support physics experiments.
IST Austria is located in the city of Klosterneuburg, a suburb of Vienna known for its high standard of living. The location of IST Austria's campus amidst the hills of the Vienna woods provides a tranquil and stimulating environment for scientific research. The city of Klosterneuburg offers educational, medical, cultural, and recreational facilities of the highest standard.

The historical center of Klosterneuburg is dominated by its medieval monastery, redesigned in the Baroque style as a residence for the Austrian emperor in the early 18th century. The Essl Museum, world-famous for its collection of contemporary art, is located close to the city center. Our immediate neighbor on campus is the internationally renowned Art Brut Center Gugging.

IST Austria can be reached easily by public and individual transportation, including the IST Austria shuttle bus 242 from the subway station Heiligenstadt in Vienna.
Winter impressions

Flowing progress

The campus of IST Austria is expanding to provide infrastructure for excellent research. Currently, the Raiffeisen Lecture Hall, Central Building, Bertalanffy Foundation Building, Lab Building East, voestalpine Building and Miba machine shop are in operation.
see you in 2014