IST AUSTRIA
Institute of Science and Technology

Annual Report 2015

Content

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IST Austria Scientists

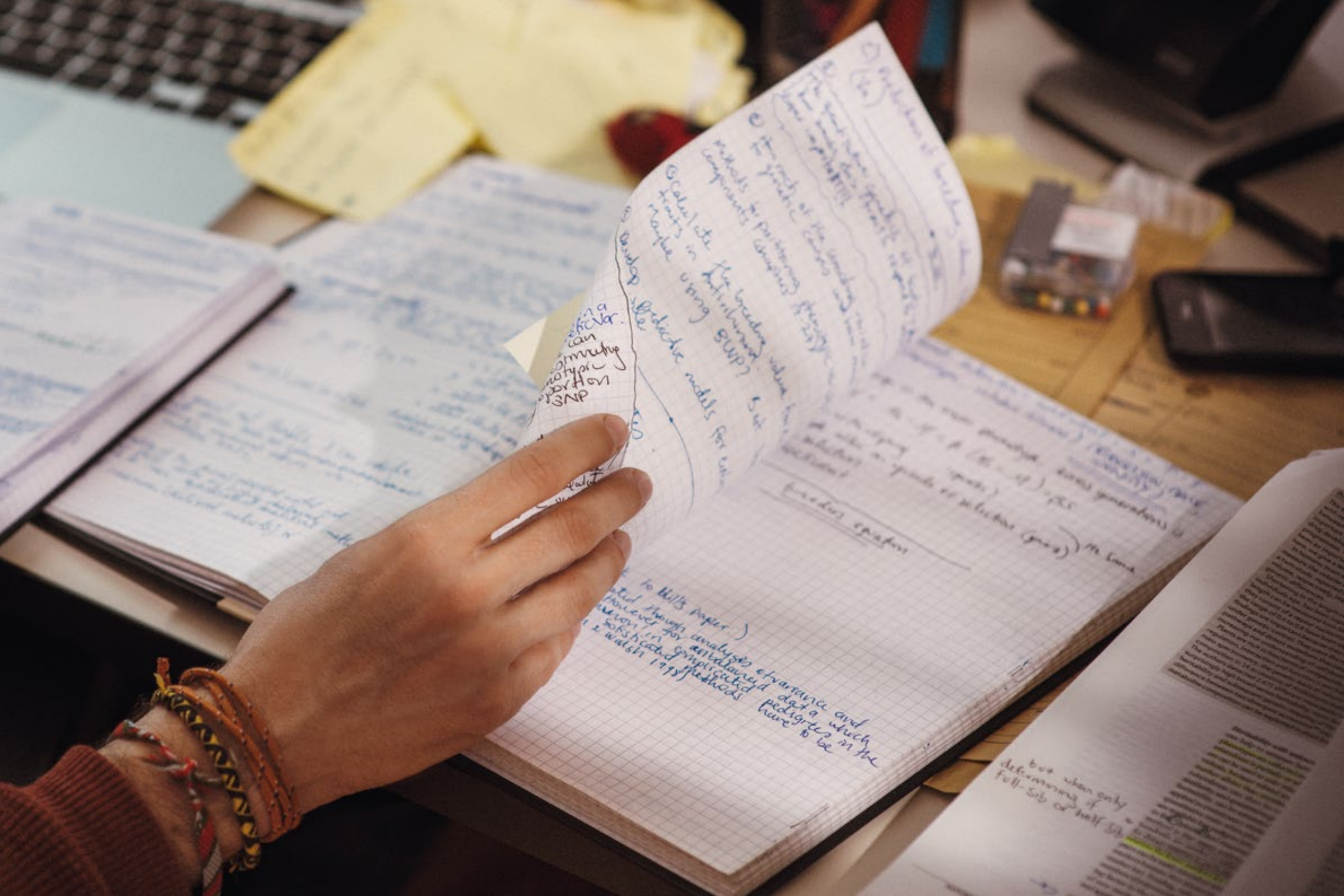
Scientists from all over the world come to IST Austria. The world map gives an overview of their nationalities on campus.

Based on location of previous institution

16.8%	Germany	
12.8%	Austria	
9.8%	USA	
7.3%	UK	
4.0%	Switzerland	
4.0%	France	
3.7%	Belgium	
3.4%	Italy	
3.4%	Czech Republic	
3.0%	Spain	
2.4%	Japan	
2.4%	Canada	
2.4%	China	
2.1%	Russia	
2.1%	India	
20.4%	others	

Based on nationalities

13.4%	Austria	
12.2%	Germany	
6.1%	China	
4.9%	Slovakia	
4.6%	India	
4.6%	Czech Republic	
4.3%	Italy	
4.0%	Russia	
3.4%	Poland	
3.4%	Spain	
3.0%	UK	
2.7%	Hungary	
2.7%	France	
2.1%	Switzerland	
2.1%	Japan	
26.5%	others	



Foreword

Thomas A. Henzinger
President, IST Austria

The past twelve months were, once again, a year of substantial growth for IST Austria. The number of employees recently surpassed 500. Coming from almost 50 different countries, they turn the campus into a truly international place for science. In December 2015, we saw the official opening of our newest — and so far, largest — building on campus. The Laboratory Building West will become the home for up to 30 research groups in physics and mathematics and house a state-of-the-art nanofabrication facility for solid-state physics.

In 2015, three new professors in neuroscience, cell biology, and mathematics — selected out of more than 900 applicants — signed a contract with IST Austria, bringing the total number of faculty to 40. Evolutionary biologist Sylvia Cremer and computer scientist Christoph Lampert were promoted to tenured professors. With the four ERC grants awarded in 2015 to the biologists Jon Bollback, Anna Kicheva, Martin Loose, and to the computer scientist Krzysztof Pietrzak, and including the ERC grants that will be brought to campus in 2016 by the mathematician Tamás Hausel and the physicist Georgios Katsaros, exactly half of our 40 professors are currently supported by the European Research Council. This puts IST Austria into the top league of scientific institutions in Europe.

The Graduate School acquired the biggest single grant for IST Austria so far — EUR 4.4 million from the European Union for our ISTScholar program — bringing the total amount of competitively acquired external funding to more than EUR 50 million in six years. The ISTScholar program supports students in the interdisciplinary PhD program of IST Austria during their first years of study. A new private donor, Klaus Pöttinger, supports three PhD students with dedicated scholarships.

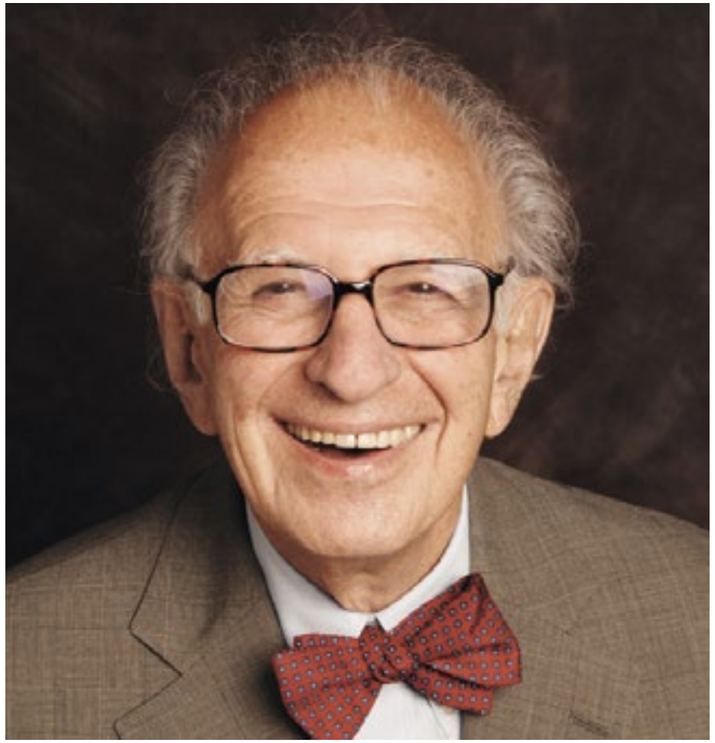
In its first six years, IST Austria has awarded 14 doctoral degrees and 94 postdocs have left the Institute to move on to their next career steps. The reputation of the Institute will depend just as much on the future achievements of our student and postdoc alumni as on the research results of the faculty. In the past year, former IST Austria postdocs took up faculty positions in Japan and Poland.

Over the past two years, a detailed, comprehensive administrative and financial review of IST Austria was carried out, commissioned jointly by the Federal Ministry of Science, Research, and Economy and the State of Lower Austria. The review team concluded that the Institute can serve as a role model not only for excellence in science, but also for excellence in science administration. We will use their findings as a source of inspiration for further improvement.

A firm and long-term commitment forms the foundation of all success in basic research. We thank in particular the Federal Minister for Science, Research, and Economy, Vice-Chancellor Reinhold Mitterlehner, and the Governor of Lower Austria, Erwin Pröll, for their strong support of IST Austria and for the recent reaffirmation of their long-term commitment. With the continued backing by the many friends of the Institute, the dedicated performance of our employees, and new sources of private funds, IST Austria will no doubt be able to continue to prove that ambitious projects, executed with an unswerving focus on excellence, can and will succeed.

Guest Commentary

by Eric Kandel



Kandel, an American neuroscientist and Nobel laureate, has been a member of the Board of Trustees of IST Austria since 2006.

In 2008, I was asked to give my view on IST Austria in an interview. I expressed my high expectations: With a combination of solid administrative leadership and excellent resources provided by the national and Lower Austrian governments, the Institute is in a superb position to accomplish something really important. Seven years later, I am asked again to reflect on IST Austria's achievements in the light of my previous statement. The Institute is indeed off to a brilliant start and already has, if anything, exceeded my expectations.

IST Austria has recruited outstanding people ranging from computer science to evolutionary biology to brain science to structural biology. Thus, IST Austria has succeeded in bringing together scientists from different disciplines who perform interesting research — each of them with their own interests but with overlapping work activities. This has produced a new level of integration to the science previously being carried out in Austria or in most parts of Europe for that matter.

This is only the beginning of a great institution whose future is very promising. So what should we expect for the next seven years, apart from scientific excellence? I hope to see more female members of the faculty. I would also like to see more developments in brain imaging. And who knows, maybe someone here will start studying higher cognitive functions like attention or consciousness. Ultimately, the study of consciousness began in Vienna with Freud, why should it not be continued at IST Austria?

"IST Austria was built on the idea of bringing together scientists from different disciplines in order to perform research — each of the scientists with their own interests but with overlapping interests and research activities."

Boards of IST Austria

"The scientific quality at IST Austria is proven by the number of ERC grants as well as by the excellent scientists who have decided to continue their career in Klosterneuburg. Since the beginning in 2009, there has been an amazing increase of scientific output and also reputation within the community. But the remarkable performance is not restricted to science and research alone. The evaluation of economic factors that was published in 2015 shows a very responsible use of taxpayers' money. Of course, there is always room for improvement in the economic as well as in the scientific fields. But the direction of IST Austria is the right one—it is an important contribution to Austria's way to becoming an innovation leader and strengthens the position of Austria as a key player in basic research."

Reinhold Mitterlehner
Vice-Chancellor; Federal Minister of Science, Research and Economy

"For the Federal State of Lower Austria, research, technology, and innovation are central contributions to securing the future: every Euro invested in these areas is an investment in the future of the generations to come and serves to enhance the state's innovative and economic strength. It is on the basis of this premise that Lower Austria has flourished and become a vibrant science hub in the past two years. Needless to say, IST Austria plays a central role in this regard. While the competition for the location of the campus caused criticism in the past, these voices have now fallen silent, because IST Austria is well underway to becoming an established research institute of international standing. The creation of such international gravitational pull represents a key goal of Lower Austria's science policy also because we aspire to be perceived in the international arena as a state that does not restrict science and heeds its findings."

Erwin Pröll
Governor of Lower Austria

7 Apprentices

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112 Research grants acquired or active

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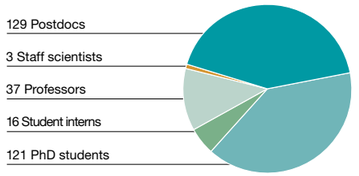
283 Publications 2015

462 Scientific visitors 2015

IST Austria at a Glance

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

306 Scientists



Faculty positions

Applications for faculty positions	1'206
Faculty offers made	5
Faculty offers accepted	3

Student positions

Applications for student positions	1'387
Student offers made	53
Student offers accepted	39
PhD graduates	3

Research grants (rounded amounts; acquired or active in 2015)

ERC European Research Council	30'196'000 €
EU other	11'280'000 €
FWF Austrian Science Fund	10'083'000 €
HFSP Human Frontier Science Program	1'579'000 €
ÖAW Austrian Academy of Sciences	627'000 €
DFG Deutsche Forschungsgemeinschaft	591'000 €
EMBO Excellence in the life sciences	410'000 €
WWTF Vienna Science and Technology Fund	323'000 €
NFB NÖ Forschung und Bildung	245'000 €
SNF Swiss National Science Foundation	174'000 €
Microsoft Research	151'000 €
Others	555'000 €
Total	56'214'000 €

IST Austria was established by the federal government of Austria and the government of Lower Austria and was inaugurated in 2009. The development plans for IST Austria allow for a growth to about 90 research groups by 2026. The Institute is located in the city of Klosterneuburg on the outskirts of Vienna.

COMMITTED TO EXCELLENT SCIENCE

The scientists are organized into independent research groups, each headed by a professor or a tenure-track assistant professor. The Institute chooses which fields of science to enter based solely on the availability of outstanding individuals. It will pursue a direction of research only if it can compete with the best in the world. The Institute is evaluated regularly by leading international scientists and science administrators.

Research excellence and promise are the exclusive hiring criteria for all scientists at IST Austria — from doctoral students to professors. The Graduate School of IST Austria educates doctoral students from around the world to become researchers. The decision to promote an assistant professor to professor with a permanent contract is based entirely on an evaluation by international experts of the scientific achievements of the assistant professor.

IST Austria fosters an interdisciplinary scientific atmosphere: the Institute offers a single PhD program with courses for graduate students in all fields of the natural and formal sciences. Hierarchical and separating organizational structures such as departments are avoided.

DIVERSE FUNDING

The long-term financial health of IST Austria will rely on four different sources of funding: public funding, national and international research grants, technology licensing, and donations. For the period from 2007 to 2026, the federal government of Austria provides up to EUR 1'280 million in operational funds. Two thirds are guaranteed while the remaining third is dependent on performance-related criteria such as the raising of third-party funds. The state of Lower Austria covers the costs for construction and campus maintenance in the amount of EUR 510 million from 2007 to 2026.

INDEPENDENT LEADERSHIP

The governance and management structures of IST Austria guarantee the Institute's independence from political and commercial influences. 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. He is supported by Vice President Michael Sixt, who oversees the operation of the Scientific Service Units. The administration of IST Austria is led by the Managing Director, Georg Schneider.

More information on IST Austria can be found at *www.ist.ac.at*, where you can also sign up for the Institute's quarterly newsletter.

Training the Next Generation of Scientists

The Marie Skłodowska-Curie actions are a funding program created by the European Union to support researchers at all stages of their careers, irrespective of nationality. It was named after the two-time Nobel Prize-winning Polish-French scientist, renowned for her work on radioactivity.

The Marie Skłodowska-Curie COFUND program is specifically designed to foster mobility of early-stage scientists within and into the European Union. The competitive program co-funds 40% of the expenses of an institution's program.

IST Austria successfully applied for two Marie Skłodowska-Curie COFUND grants and received considerable amounts of funding to complement the Institute's own expenses for the Graduate School and for the institutional postdoctoral fellowship program ISTFellow. COFUND is based on the "Triple-I" principles of internationality, interdisciplinarity, and intersectoral mobility, which are a perfect match to the structured doctoral and postdoctoral trainings at IST Austria. The culture at the Institute emphasizes inter- and multidisciplinary science as well as pure, curiosity-driven research. A core aim is to break down traditional boundaries between disciplines, thereby fostering a free exchange of knowledge between researchers from different disciplines. In this way, IST Austria seeks to pave the way for new frontiers in research and in graduate education.

POSTDOCTORAL TRAINING PROGRAM ISTFELLOW

In 2012, the postdoctoral program ISTFellow was awarded EUR 3.4 million, covering 40% of the total of EUR 8 million project costs. In semiannual intervals, IST Austria issued altogether six calls for postdoctoral fellowship applications that were advertised world-wide; the last call co-financed by the COFUND program was open in 2015.

A transparent, central selection process for ISTFellows, which was conducted by internal and external selection committee members, judged primarily the scientific excellence and promise of the applicants. Overall, 46 ISTFellows were chosen and funded for a period of two years each. ISTFellows are employed with full-time contracts, allowing them to pursue independent research projects within the research groups they join. They also participate in a dedicated career development program which includes mentoring, supervision, and generic skills training to further improve their career prospects.

The ISTFellow program is a supplement to the Institute's regular postdoctoral program whereby applications for a postdoc position are submitted directly to professors. Inspired by its success, the ISTFellow program will be continued beyond 2015 from the Institute's own resources on a reduced scale.

DOCTORAL TRAINING PROGRAM ISTSCHOLAR

The year 2015 brought to IST Austria another successful application for a Marie Skłodowska-Curie COFUND grant, which was ranked first among the 49 applications from across Europe. The Graduate School of IST Austria was awarded EUR 4.4 million for its ISTScholar program.

Within the three upcoming calls 2016–2018, 80 PhD students will be funded for up to two years each, covering the first phase of the Institute's two-step PhD program. The first cohort of ISTScholars will start in fall 2016. Again, the "Triple-I" principles of the Marie Skłodowska-Curie action — internationality, interdisciplinarity, and intersectoral mobility — are echoed in the design of the doctoral training of IST Austria. Annual calls with a deadline in mid-January will be disseminated extensively, seeking applications from all over the world for the PhD program that spans across all scientific disciplines offered at IST Austria. After a transparent selection process based on promise and excellence which includes an interview day at the Institute, successful candidates will start in fall of the same year.

In the first phase of IST Austria's PhD program, students remain unaffiliated and attend courses, lab rotations, as well as training outside their original scientific subject. After about nine months, students start to affiliate with research groups and take a qualifying exam. For the subsequent three to four years, they pursue their research projects for a doctoral thesis. The costs of the first two years, which can be seen as a training phase within the doctoral program, will be supplemented by the COFUND grant.

The Principles of Innovative Doctoral Training of the European Union encourage institutions to acknowledge the important contribution of doctoral researchers in the creation of new knowledge. They emphasize the striving for research excellence in an interdisciplinary environment, including exposure to industrial research, the provision of good working conditions, and the importance of career development programs as well as quality assurance measures.

IST Austria is dedicated to following these principles and offers ISTScholars scientific training as well as a career development program that focuses on the development of a broad set of skills, which are necessary for pursuing successful careers in and outside of academia. The program also raises the students' preparedness for the international job market.

ISTFELLOW ALUMNI

Arnaud de Mesmay, Wagner group
Jan Kretínský, Chatterjee & Henzinger groups
Fatemeh Mohammadi, Uhler group
Patrik Noren, Uhler group
Martin Tancer, Wagner group
Krzysztof Wabnik, Benková group
Shih-Ming Weng, Jonas group
Dirk Zeindler, Erdős group

ERC Grants at IST Austria

IST Austria's rapid development into a European center for frontier research is to a considerable degree due to the success rate of its scientists applying for grants of the European Research Council (ERC).

Interview with Jean-Pierre Bourguignon, President of the European Research Council

The highly competitive ERC grants have become a benchmark for excellence in research, and with 20 ERC awardees out of 40 professors, IST Austria is in the top league of European research institutions dedicated to basic science. At the end of 2015, a total of four Advanced, three Consolidator, and 13 Starting Grants have been awarded to scientists at IST Austria.

Since its foundation in 2007, the ERC has set new standards for basic science on the European level by defining schemes that are designed to promote the highest quality in research and to enable individual researchers to follow their scientific visions in a "bottom-up" approach. The ERC awards ensure that funds are given to excellent scientists with a great degree of flexibility and channeled into new and promising areas of research. This philosophy and mode of operation are in line with IST Austria's mission and thus make the ERC the ideal funding source for established researchers at the Institute who are leaders in their respective scientific fields, as well as for young, ambitious researchers joining the Institute to become such leaders.

Professor Bourguignon, the ERC has been established in 2007 and today is seen as the most successful funding structure for science in Europe—mission accomplished?

JPB: I would not put it this way. Because of its huge success the ERC has the obligation to aim even higher, and we must push for more resources to enhance more first-rate curiosity-driven research in Europe. The ERC has demonstrated the enormous potential available in the European Research Area. Now we want to take it at least one step further: we want to attract research talent to come to European hubs of science or enable them to stay at excellent research institutions on this continent. This is vital because European institutions are competing against other top-class research centers on a global scale.

One of great benefits for ERC awardees is that they are free to perform the funded research at their institution of choice. Do you have indications to what degree these funding schemes contribute to mobility?

JPB: The ERC definitively makes a difference in this respect. And we observe that ERC grants have a gravitational pull for talent in science towards those institutions that strive to provide an optimal infrastructure on many levels. These organizations are able to attract or retain ERC-funded scientists to a much greater extent than those where ERC grants are rare.

Does Horizon 2020 provide the necessary stability for the ERC funding schemes to keep growing?

JPB: Yes and no. We want to make the ERC success story as robust as possible and want to safeguard the continuation of this success. The total budget a priori allocated to the ERC for the period 2014–2020 is more than EUR 13 billion. This is substantial, but we will have to see what the allocation will be after the midterm review due for 2017. Actually, I made the point to the Budgets Committee of the European Parliament that additional funds will be needed to broaden the ERC's scope a bit and to send out the right signals to the international scientific community: Come, stay here, and help enlarge the science base of this continent! And it would be wrong to take for granted the accomplishments we have seen in European science in the past years. The race for talent is tough, and our global competitors want to get into the driver's seat just as much as we do.

What are the key factors for the ERC to stay successful?

JPB: The ERC provides a concept that is understood all around the world. It offers a generic and coherent set of funding schemes favoring young researchers, that make researchers better and stronger by applying the rule "keep it as simple as possible—make it as effective as possible". Yet, the backing of the scientific community is essential to keep the momentum on our side. Without the researchers' support for the ERC, we would have too little weight in the European struggle for resources. So scientists should not take anything for granted. This is crucial for ERC to stay successful.

ERC CORE FUNDING SCHEMES IN A NUTSHELL

The ERC is a key component of Horizon 2020, the European Union's Research Framework Program for 2014 to 2020, and complements other funding activities in Europe such as those of national research funding agencies. Its core funding schemes are:

ERC Starting Grants for top researchers with 2–7 years of experience after PhD, grants up to EUR 1.5 million for a funding period of five years

ERC Consolidator Grants for top researchers with 7–12 years of experience after PhD, grants up to EUR 2 million for a funding period of five years

ERC Advanced Grants for established researchers with a recent research track record which identifies them as leaders in their respective field of research, grants up to EUR 2.5 million for a funding period of five years

Lab Building West

A new building for experimental and theoretical sciences. Lab Building West, the fifth and so far biggest building at IST Austria, was opened in December 2015.

Located on the western part of the campus, it is a significant milestone for completing the ring of buildings that surround the pond and the green areas in the center of the campus. Lab Building West provides 10'000 sqm of floor area spread over six stories to accommodate up to 30 research groups. It is designed for the requirements of experimental research in the physical sciences as well as theoretical research.

FESTIVE OPENING

Lab Building West was inaugurated on December 1. Many high-ranking guests attended the festive opening, including Reinhold Mitterlehner, Vice Chancellor and Minister of Science, Research, and Economy, Erwin Pröll, Governor of Lower Austria, as well as the Chairman of the Board of Trustees of IST Austria, Claus Raidl, and the Chairman of the Executive Committee of the Board, Haim Harari. The opening was followed by guided lab tours which included a demonstration of the Meissner effect and quantum levitation.

A NEW RESEARCH FACILITY

Lab Building West will enable a considerable widening of the scope of research performed at IST Austria through the Nanofabrication Facility. This newly established Scientific Service Unit is located on two floors of the building and will start operating in late 2016. It will allow novel materials and devices to be fabricated and studied free from any contaminants in a cleanroom spanning 310 sqm. For the first time, solid-state physicists and material researchers will be able to carry out experiments at IST Austria and investigate, for instance, new ways of information processing in computers. The flexible structure of Lab Building West allows for state-of-the-art research infrastructure operated by highly specialized experts. More information on the future services can be found at *http://ist.ac.at/ssus*.

THE BUILDING

Lab Building West was designed by the architects at Baumschlager Eberle and opened after just 30 months of construction, which was entirely funded by the State of Lower Austria. It comprises two blocks of six floors each, including the basement and a set back roof top for building services. A bridge connects the office block with the lab block and serves as a communication area — a concept that was effective with the connection between the Central Building and Bertalanffy Foundation Building. Lab Building West will be heated and cooled through thermal concrete core activation. Photovoltaic elements on the roof top produce energy for the building.

SOLID-STATE PHYSICS IN LAB BUILDING WEST

The solid-state physicists Johannes Fink and Georgios Katsaros, Assistant Professors at IST Austria, aim to contribute to our understanding of matter and the development of new materials and devices. Their experimental research will be carried out in the newly opened Lab Building West, which will include a Nanofabrication Facility.

Nano-scale semiconductor devices have been critical to the development of modern computing. Computers have revolutionized our lives in ways that were unconceivable only a few decades ago. They have become ever more powerful at incredible speed and at the same time got increasingly reduced in size. Even the smartphone in our pocket is a million times more powerful than NASA's computing capacity that enabled the landing on the moon in 1969. "This is all down to Moore's law", explains Johannes Fink, Assistant Professor at IST Austria. "Computers are predicted to become smaller and smaller. Eventually, we will reach a limit where the conducting paths are only a few atoms wide. Quantum effects will arise which are undesirable for current computing — but scientists world-wide seek to harness them to build a better computer, ultimately a quantum computer."

The devices used by Georgios Katsaros already have a height of just 15–20 atoms. He investigates fundamental new concepts on which quantum computing could be based in the future. Though the aim is not to build a quantum computer as such, he tries to understand the underlying physics. Katsaros explains his motivation: "Science will be able to fulfill Richard Feynman's vision of using a quantum computer to simulate quantum systems, which we need so we can at least begin to understand these quantum systems."

Katsaros develops nano-devices based on Germanium semiconductors and studies the quantum effects that appear when these nano-transistors are being cooled down. One of the quantum mechanical properties of a charge carrier is its spin. Katsaros' aim is to investigate such quantum bits or qubits by manipulating them with microwaves. In classic computers, a bit can be in two states, ON or OFF. In quantum computers, a qubit can be both ON and OFF at the same time. The more qubits a quantum computer combines, the more states it can address in parallel and the faster it can compute. Katsaros' group is interested both in spin qubits as well as Majorana fermions; the latter have been suggested as the building block of a so called topological quantum computer. Such a computer would be completely protected from the environment, which can destroy the information carried by electrons. Theory posits that an electron can be split into "two" parts, the so called Majorana fermions. In the topological quantum computer, both Majorana fermions have to be perturbed at the same time to destroy the quantum information. So far, there have been reports about signatures of Majorana fermions but the absolute proof is still missing and even more importantly, no studies exist so far addressing their real potential for quantum computing.

Johannes Fink's research is positioned at the intersection of light and matter, or more precisely between quantum optics and mesoscopic condensed matter physics. One of his goals is to convert an invisible microwave photon to a visible, optical photon while conserving its fragile quantum state. In the cleanroom of Lab Building West, Fink and his group will develop a "router" together with the necessary chip that will be able to convert a microwave signal to an optical signal. A possible future application might even be a router for a prospective internet of superconducting quantum computers: since they emit microwave signals, a transformation would be required to be able to send conventional optical signals via telecom fibers.

Fink however will use these devices to perform quantum optical experiments with artificial atoms and microwave photons. For example, he will use a superconducting qubit to create a single photon state, in which only one photon is generated with 100% certainty. With his router, this microwave photon can be converted into an optical photon that can be detected and verified with conventional optical detectors. Fink also wants to entangle microwave photons with optical photons to develop more sensitive imaging techniques. Delicate systems may be destroyed if imaged with optical photons. Through so-called quantum ghost imaging, a microwave photon is instead sent into the system. Researchers in turn read the information from the entangled optical photon, which has never itself interacted with the imaged object.

While transistors have become smaller and smaller, it is not yet known how to continue this trend with quantum devices, as Johannes Fink admits: "We need to cool our devices to 0.01K — which is much colder than the universe — and our cooler is the size of an industrial fridge."

Research Highlight Neuroscience

Inside the Head

Neuroscientists investigate the nervous system to ultimately understand how our brains work, how we manage to think, learn, and remember, and how we coordinate our actions by transmitting signals through our body at incredible speed.

Today, neuroscience has evolved into a highly interdisciplinary area. No longer is it exclusive to biology or medicine but has strong links to disciplines such as computer science, mathematics, or physics. Consequently, neuroscientists investigate a wide range of aspects in the nervous system as they reveal the secrets of molecules, cellular processes, and neuronal circuits.

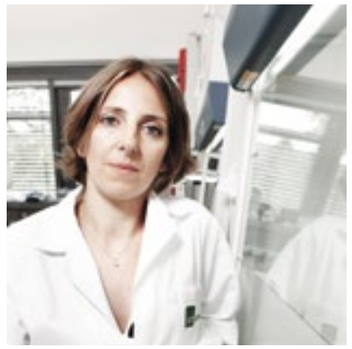
This diversity is reflected by the academic backgrounds of the neuroscientists working at IST Austria. Yet, they all have a strictly quantitative approach in common as they elucidate different aspects of the nervous system: How are memories built and the cerebral cortex developed? How do synapses communicate, how is information processed, and what is the function of specific molecules? What are the genetic and molecular bases of neurodevelopmental disorders, which interactions between specific cell types cause diseases?

Understanding the microcosm of the nervous system and its components also requires cutting-edge technologies that are able to accurately measure infinitesimal processes. The Electron Microscopy Facility provides some of the highly sophisticated equipment, allowing scientists to peek into a single neuron (read more on page 91).

How do synapses communicate, how is information processed, and what is the function of specific molecules?

JOZSEF CSICSVARI investigates how learning leads to memory formation in the brain. In one of their projects, the Csicsvari group addressed the well-known phenomenon that sleep greatly helps to consolidate memories. In the absence of any interfering stimuli, the neuronal network is in a much better position to encode what has been learned. The research group is focusing on the hippocampus, a brain area that plays a key role in the processing of spatial information and episodic memory. During sleep, it also naturally repeats what has been learned before and sends it to other brain areas. Based on the discovery of "place cells" — i.e. spatial selective cells that have a sense of location — the group designed experiments to measure the neuronal activity in the hippocampus of rats. The animals learned where food was hidden in a maze. Csicsvari and colleagues recorded the action potential of place cells in the hippocampus during the periods of learning, sleep, and memory retrieval. The neuronal activity patterns in the sleep phase mirrored those of the learning phase and did so with more accuracy when learning took place closer to sleep. The collected data from the sleep patterns allowed actually predicting how well the animal was going to remember the locations with food. The group now aims at blocking specific spatial memories. They do so by suppressing the activity of certain place cells during sleep with optogenetic methods. These experiments produce huge amounts of data and lengthy analysis steps are necessary to process them. Future research will study how the memory traces are transferred from the hippocampus to brain regions where they are potentially stored long term.

SIMON HIPPENMEYER is one step closer to answering the fundamental question how stem cells in the developing brain produce the highly specialized neurons in the cerebral cortex — an area of the brain that commands all higher cognitive functions such as perception or language. Hippenmeyer and his team investigated a subclass of neural stem cells called radial glia progenitors or RGPs, which are responsible for producing all cortical neurons. They used a unique genetic methodology called MADM which stands for Mosaic Analysis with Double Markers. MADM provides unprecedented single-cell resolution of stem cell division pattern *in vivo,* and thus an unambiguous quantitative optical readout of the precise proliferation mode of cortical progenitors. By systematically applying MADM in RGPs, they discovered a remarkable feature: RGP development follows a clear and predefined "orderly" program that first leads to a great expansion of the stem cell pool. Yet at a certain stage, RGPs enter a special step in their developmental program where each consistently produces fixed units of about 8–9 neurons. This discovery implies a fine balance between RGP proliferation and differentiation into neurons, and suggests a precise mechanism to specify the cerebral cortex of the correct size and cellular composition.



"Eventually, we will know how synapses function and also how they fail in diseases."

PETER JONAS

"Unraveling the 'mystery' of human brain development and function represents one of the biggest but most fascinating challenges for this century"

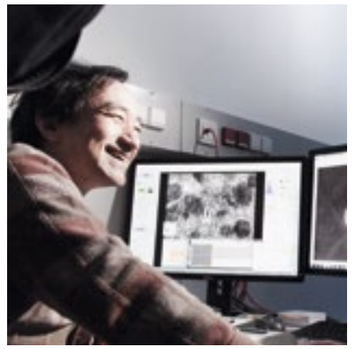
SIMON HIPPENMEYER

Hippenmeyer wants to take this research a step further to decipher the underlying cellular and molecular mechanisms, based also on human tissue: A recent breakthrough of the international neuroscientific community was the actual creation of "minibrains", derived from human stem cells, that form a cerebral structure similar to a very early embryonic human brain. This novel medium is starting to become widely used to study brain development but also the underlying basis of neurodevelopmental disorders.

PETER JONAS works on the understanding of the function of neuronal microcircuits. In line with Hopfield's famous quote "build it, and you understand it" the Jonas group is tackling a major undertaking: they are quantitatively exploring the nanophysiology of a specific type of inhibitory interneuron to eventually build a complete mathematical model. These nerve cells — the so-called fast-spiking parvalbumin-positive GABAergic interneurons — play a central role in information processing of neuronal networks in the hippocampus. One of their jobs is to convert an excitatory input signal into an inhibitory output signal within a millisecond. Checkpoints like these are the key to preventing excitatory activity to explode, as may happen in epilepsy. To achieve this kind of speed, neurons usually require a large axon diameter and a coating with myelin, yet GABAergic interneurons have neither of these. Jonas' research revealed a new subcellular mechanism for reliable and fast action potential transmission. It consists of a controlled increase in the density of Na^+ channels and conductance, starting from the cell body to the proximal axon, where action potentials are initiated. Current research is now focusing on another part of the neuron — the presynaptic terminal — from which the Jonas group is taking direct measurements. The aim is to identify all mechanisms that contribute to the speed of signaling at the synapse. It is not surprising that high velocity comes at a cost and consumes a great amount of energy. For this reason, the Jonas group is measuring the energy requirements on a subcellular level in a unique approach to establish how much "fuel" in the form of adenosine-triphosphate or ATP is needed. One of the next intriguing questions will be which evolutionary strategy the neuron took in order to find a viable compromise between speed, reliability, and energy consumption.

GAIA NOVARINO is leading a research program with a focus on inherited forms of epilepsy, intellectual disability, and autism in children. It seems that this spectrum of neurodevelopmental disorders (NDD) shares common molecular and genetic mechanisms. However, there is not one single cause but a multitude of various genetic mutations that are responsible for NDD although a group of affected people may show very similar symptoms. The presence of hundreds of different causes makes the quest for a potential cure look like a search for a needle in the haystack. Gaia Novarino and her group therefore aim to categorize genes that may be dissimilar but are contributing to same processes. A recent example is her discovery of three specific amino acids that — if not available in sufficient quantity — cause a rare form of NDD. Some patients were found to have a mutated gene that degraded these amino acids too fast, resulting in too low a level. Yet, this was not the case in other patients with the same deficiency. In her current work, Novarino therefore aims to uncover other possible factors that induce a lack of these amino acids. Another interesting question in this context is time: If a mutated gene is only active during a certain developmental window and becomes silent later in life, a potential cure would become obsolete if given too late. But if administered during the developmental window, medication — in this case the lacking amino acids — could be given up until a certain age and after that point in time, the individual would be cured.

RYUICHI SHIGEMOTO seeks to understand the molecular basis of neuronal transmission in the brain mediated by neurotransmitter receptors or ion channels. In a more experimental approach, Shigemoto and his group also examine the left-right asymmetry of the brain. This so-called laterality of the brain function is well known but the molecular determinants are still largely elusive. Most humans — and also many vertebrates — have a right hemisphere dominance for spatial navigation and memory. The reason is twofold as both genetics and environmental factors play a role. In one of Shigemoto's experiments, mice explored an enriched environment with a variety of toys (such as running wheels, tubes, etc.) as opposed to a plain standard cage.



The exploration induced a higher activity in the right than in the left hippocampus, a brain region related to spatial memory formation, and the amount of connections between neurons significantly increased exclusively in the right hemisphere of the brain as a result of the environmental changes repeated for six weeks. To study the second aspect — the genetic reasons — Shigemoto worked with mutant mice that lack the left-right asymmetry. He found that the difference in their genes is critical for the formation of lateralization and examined the pathway of this development. But what is this asymmetry actually good for?

There is no conclusive answer yet: some tasks are better accomplished by wild-type mice and maybe others by mutant mice. But in terms of spatial memory, laterality is indeed an evolutionary advantage.

SANDRA SIEGERT explores the compelling world of microglia. These cell types are not just the health police of the central nervous system but also play a vital role in the formation and function of the neuronal circuit, as recent research uncovered. Microglia can be activated in the presence of neuronal malfunction — leading to alteration of neuronal circuit elements — and then lay dormant again afterwards. However, modification within genes exclusively expressed in microglia could also take action causing microglia to attack healthy cells.

To understand how microglia are switched on and whether they are causative for a disease, Siegert examines their role in the case of retinitis pigmentosa, a disease where the photoreceptor cells die off and which shows microglial activation. The retina represents an ideal model system to study microglial function because of the well-defined and precisely mapped neuronal circuits. Siegert combines various approaches to unravel the unknown mechanisms of microglia: Live imaging of microglial cells, which express green fluorescent protein, and photoreceptors, which express red fluorescent protein, will tell us more about the interaction of microglia and neurons during health and disease. Moreover, Siegert and her team can model the observations in "mini-retinas", generated from induced pluripotent stem cells obtained from human skin cells. They will genetically modify the disease-associated genes of microglial cells to reveal the subsequent effects. In the long run, an understanding of the microglial system will potentially have tremendous benefits, and not just for people with degenerative eye diseases: microglia are involved in a multitude of neurodegenerative disorders like Alzheimer's or Parkinson's disease, to name just a few.

"It's important to combine neurobiology with the neuroglia field to get a full picture of disease conditions"

SANDRA SIEGERT

GAŠPER TKAČIK is a theoretical physicist and computational neuroscientist. One strand of his current interdisciplinary research investigates how the neural code works in the eye's retina. The retina transforms light signals into sequences of spikes and silences, and these so-called action potentials are sent through the optic nerve to the brain. Together with a group of experimentalists at the Institut de la Vision in Paris, they studied these visual signals while a movie was being shown and precisely recorded the output consisting of action potential spikes. The Tkačik group developed a mathematical model to reconstruct the original movie stimulus from the recorded signals of the retina with good accuracy. For this recent experiment, the researchers used a rich artificial stimulus of dark discs moving around randomly, but decoding complete natural movies still remains very challenging.

Gašper Tkačik and his colleagues are now striving to better understand the workings of the retina so that they can build improved decoders for natural movies. They are using methods from machine learning and information theory in order to quantify how precisely the retina transmits information. Results of their theoretical work may also feed into ongoing experiments of applied groups that seek to restore the vision of patients with retinal degeneration by means of a little camera coupled to a chip that stimulates retinal neurons.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Research at IST Austria

Currently, research at IST Austria focuses on basic research in the life sciences,the formal sciences, and the physical sciences. Interdisciplinary networks facilitate scientific collaborations between theoretical and experimental researchers.

Eva Benková

Cell & Molecular Biology

Tobias Bollenbach

Jiří Friml

Călin Guet

Carl-Philipp Heisenberg

Harald Janovjak

Anna Kicheva

Martin Loose

Leonid Sazanov

Daria Siekhaus

Michael Sixt

Computer Science

Bernd Bickel

Krishnendu Chatterjee

Thomas A. Henzinger

Vladimir Kolmogorov

Christoph Lampert

Krzysztof Pietrzak

Chris Wojtan

Evolutionary Biology

Nick Barton

Jonathan P. Bollback

Sylvia Cremer

Beatriz Vicoso

Mathematics

Herbert Edelsbrunner

László Erdős

Jan Maas

Caroline Uhler

Uli Wagner

Neuroscience

Jozsef Csicsvari

Simon Hippenmeyer

Peter Jonas

Gaia Novarino

Ryuichi Shigemoto

Sandra Siegert

Physics

Björn Hof

Mikhail Lemeshko

Robert Seiringer

Gašper Tkačik

Nick Barton

Mathematical Models 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 | Speciation & hybridization in *Antirrhinum*

Selected Publications

Polechova J, Barton NH. 2015. Limits to adaptation along environmental gradients. Proc. Natl. Acad. Sci. (USA) 112: 6401-6406.

Barton NH, Turelli M. 2011. Spatial waves of advance with bistable dynamics: cytoplasmic and genetic analogs of the Allee effect. American Naturalist. 178(3), E48-75.

Barton NH, Briggs DEG, Eisen JA, Goldstein DB, Patel NH. 2007. Evolution. Cold Spring Harbor Laboratory Press.

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.

Career

since 2008 Professor, IST Austria
1990–2008 Reader/Professor, University of Edinburgh, UK
1982–1990 Lecturer/Reader, University College London, UK
1980–1982 Demonstrator, Cambridge University, UK
1979 PhD, University of East Anglia, Norwich, UK

Selected Distinctions

ISI Highly Cited Researcher
2013 Erwin Schrödinger Prize, Austrian Academy of Sciences
2013 Mendel Medal, German National Academy of Sciences Leopoldina
2009 Linnean Society Darwin-Wallace Medal
2009 ERC Advanced Grant
2006 Royal Society Darwin Medal
2001 President, Society for the Study of Evolution
1998 American Society of Naturalists President's Award
1994 Fellow, Royal Society of London
1994 David Starr Jordan Prize

Studies of hybridization between red- and yellow-flowered Antirrhinum in the Pyrenees tell us about the process of speciation.

Team Thomas Ellis (PhD student), Xavier Erny (scientific intern), David Field (postdoc), Tamar Friedlander (joint ISTFELLOW postdoc with Guet and Tkačik groups), Maria Melo Hurtado (postdoc), Sebastian Novak (PhD student), Tiago Paixao (postdoc), Pavel Payne (joint PhD student with Bollback group), Melinda Pickup (postdoc), Tadeas Priklopil (joint ISTFELLOW postdoc with Chatterjee groups), Taylor Reiter (scientific intern), Harald Ringbauer (PhD student), Himani Sachdeva (ISTFELLOW postdoc), Srdjan Sarikas (postdoc), Eniko Szep (PhD student), Barbora Trubenova (postdoc), Murat Tugrul (PhD student), Hildegard Uecker (postdoc)

Eva Benková

Plant Developmental Biology

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

Selected Publications

Marhavý P, Duclercq J, Weller B, Feraru E, Bielach A, Offringa R, Friml J, Schwechheimer C, Murphy A, Benková E. 2014. Cytokinin Controls Polarity of PIN1-Dependent Auxin Transport during Lateral Root Organogenesis. Curr Biol. 24(9):1031-1037.

Marhavý P, Vanstraelen M, De Rybel B, Zhaojun D, Bennett MJ, Beeckman T, Benková E. 2013. Auxin reflux between the endodermis and pericycle promotes lateral root initiation. EMBO J. 32:149-158.

Bielach A, Podlešáková K, Marhavý P, Duclercq J, Cuesta C, Müller B, Grunewald W, Tarkowski P, Benková E. 2012. Spatiotemporal regulation of lateral root organogenesis in Arabidopsis by cytokinin. Plant Cell. 24:3967-3981.

True to their names' Greek roots, plant hormones "set in motion" a myriad of 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.

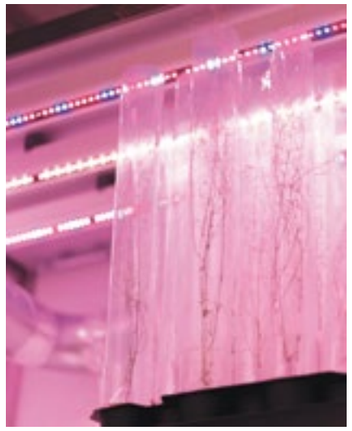
Plant hormones regulate a multitude of processes, often overlapping and modulating their effects. The two hormones auxin and cytokinin show just how complicated these interactions can be: while they act together to promote cell division, they act antagonistically when regulating the lateral growth of 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.

Career

since 2013 Assistant Professor, IST Austria
2011–2013 Group Leader, Central European Institute of Technology (CEITEC), Brno, Czech Republic
2007–2013 Group Leader, Flanders Institute for Biotechnology, Ghent, Belgium
2003–2007 Habilitation position, University of Tübingen, Germany
2001–2003 Postdoc, Centre for Plant Molecular Biology, Tübingen, Germany
1998–2001 Postdoc, Max Planck Institute for Plant Breeding, Cologne, Germany
1998 PhD, Institute of Biophysics of the Academy of Sciences of the Czech Republic, Brno, Czech Republic

Selected Distinctions

2011 FWO Grants
2008 ERC Starting Grant
2003–2007 Margarete von Wrangell Habilitation Program
2014 FWF–ANR bilateral grant



Plants in the plant growth chamber.

Team Melinda Abas (senior laboratory technician), Sonia Accossato (scientific intern), Nicola Cavallari (ISTFELLOW postdoc), Candela Cuesta Moliner (postdoc), Marcal Gallemi Rovira (postdoc), Karla Huljev (joint PhD student with Heisenberg group), Andrej Hurny (PhD student), Mamoona Khan-Djamei (postdoc), Juan Montesinos López (postdoc), Krisztina Ötvös (postdoc), Qiang Zhu (postdoc)

Bernd Bickel

Computer Graphics and Digital Fabrication

Current Projects

Computational synthesis of metamaterials | Simulating and reproducing fundamental material properties, such as elasticity, surface reflectance, and subsurface scattering | Computational design of cyber-physical systems

Selected Publications

Bermano AH, Beeler T, Kozlov Y, Bradley DJ, Bickel B, Gross MH. 2015. Detailed spatio-temporal reconstruction of eyelids. 34. SIGGRAPH: Special Interest Group on Computer Graphics and Interactive Techniques (4). ACM. Article number: 44.

Martin T, Umetani N, Bickel B. 2015. OmniAD: Data-driven omni-directional aerodynamics. 34. SIGGRAPH: Special Interest Group on Computer Graphics and Interactive Techniques (4). ACM. Article number: 113.

Schumacher C, Bickel B, Rys J, Marschner S, Daraio C, Gross MH. 2015. Microstructures to control elasticity in 3D printing. 34. SIGGRAPH: Special Interest Group on Computer Graphics and Interactive Techniques (4). ACM. Article number: 136.

We are currently witnessing the emergence of novel, computer-controlled output devices that provide revolutionary possibilities for fabricating complex, functional, multi-material objects and meta-materials with stunning optical and mechanical properties. Leveraging the potential of advanced 3D printing technology is tightly coupled to efficient methods for content creation.

Bernd Bickel is a computer scientist interested in computer graphics and its overlap into animation, biomechanics, material science, and digital fabrication. The main objective of his research group is to push the boundaries of how functional digital models can be efficiently created, simulated, and reproduced. Given the digital nature of the process, three factors play a central role: computational models and efficient representations that facilitate intuitive design, accurate and fast simulation techniques, and intuitive authoring tools for physically realizable objects and materials. Accordingly, the work of the Bickel group focuses on two closely related challenges: (1) developing novel modeling and simulation methods, and (2) investigating efficient representation and editing algorithms for materials and functional objects.

Career

since 2015	Assistant Professor, IST Austria
2012–2014	Research Scientist and Research Group Leader, Disney Research Zurich
2011–2012	Visiting Professor, TU Berlin
2011–2012	Postdoc, Disney Research Zurich
2010	PhD, ETH Zurich

Selected Distinctions

2015	Microsoft Visual Computing Award
2012	EUROGRAPHICS Best PhD Thesis
2011	ETH Medal for outstanding dissertation

Assemblage of microstructures that approximates the desired elastic behavior and requires only a single material for fabrication.

Team Thomas Auzinger (postdoc), Ruslan Guseinov (PhD student), Mathias Lepoutre (scientific intern), Luigi Malomo (scientific intern), Eder Miguel (postdoc), Ran Zhang (PhD student)

Jonathan P. Bollback

Microbial Experimental Evolution and Statistical Genomics

Current Projects

The rate of adaptive evolution in sexual and asexual populations | The evolution of an adaptive heritable immune system in bacteria

Selected Publications

Lagator M, Igler C, Moreno A, Guet C, Bollback JP. 2015. Epistatic interactions in the Arabinose cis regulatory element. Molecular Biology and Evolution. 33(3), 761–769.

Kupczok A, Bollback JP. 2013. Probabilistic models for CRISPR spacer content evolution. BMC Evolutionary Biology. 13:54.

Bollback JP, Huelsenbeck JP. 2009. Parallel genetic evolution within and among bacteriophage species of varying degrees of divergence. Genetics. 181(1), 225-234.

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.

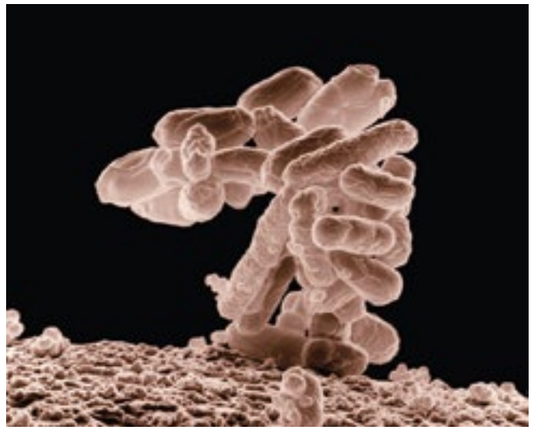
Microbes – viruses, bacteria, Archaea, and protists – account for half of the world's biomass, the majority of the biological diversity on Earth, and are the culprits of many human diseases. Microbes are also an extraordinarily powerful model system for understanding how evolution works. By studying 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 the evolutionary dynamics of host-parasite interactions. Lastly, microbes can readily donate and receive genes, via a process called horizontal gene transfer, from other individuals and species. Yet it is unclear what evolutionary forces are acting to promote and restrict this process.

Career

since 2010	Assistant Professor, IST Austria
2008–2010	Postdoc, Interdisciplinary Centre for Human and Avian Influenza Research, University of Edinburgh, UK
2004–2008	Postdoc, University of Copenhagen, Denmark
2004	PhD, University of Rochester, USA

Selected Distinctions

2007–2009	Forskningsradet for Natur og Univers, FNU Grant
2007	Featured in Aktuel Naturvidenskab nr 3 (Current Science)
2006	Forskningsradet for Sundhed og Sygdom, FSS Grant
1995–1998	Predoctoral Fellow, Smithsonian Institution, USA



A cluster of Escherichia coli.

Team Hande Acar (PhD student), Claudia Igler (joint PhD student with Guet group), Fabienne Jesse (PhD student), Mato Lagator (ISTFELLOW postdoc), Pavel Payne (joint PhD student with Barton group), Katharina Pöcher (scientific intern), Isabella Tomanek (joint PhD student with Guet group), Xiaoyun Tu (postdoc)

Tobias Bollenbach

Biophysics and Systems Biology

Current Projects

Cellular responses to conflicting signals | Mechanisms of drug interactions | Physical descriptions of animal development

Selected Publications

Bollenbach T, Kishony R. 2011. Resolution of gene regulatory conflicts caused by combinations of antibiotics. Molecular Cell. 42(4), 413-425.

Bollenbach T, Quan S, Chait R, Kishony R. 2009. Nonoptimal microbial response to antibiotics underlies suppressive drug interactions. Cell. 139(4), 707-718.

Kicheva A*, Pantazis P*, Bollenbach T*, Kalaidzidis Y, Bittig T, Jülicher F, González-Gaitán M. 2007. Kinetics of morphogen gradient formation. Science. 315(5811), 521-525.

**equal contribution*

Cells perceive a broad spectrum of signals. But how are these signals processed in the cell? And how are conflicts between different signals resolved? The Bollenbach group uses a quantitative approach to understand cellular information processing.

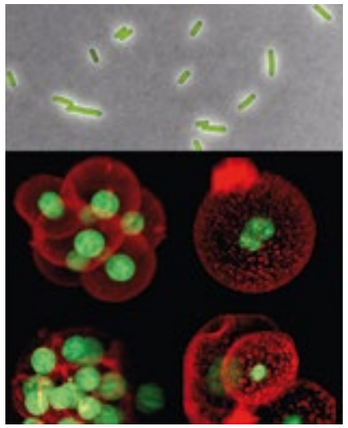
Cells need to respond to a variety of signals in their environment, such as nutrients, drugs and signaling molecules. The Bollenbach group studies how cellular responses are computed and integrated, particularly in environments that contain multiple, potentially conflicting, signals. The experimental system the group currently focuses on is the bacterial response to combinations of antibiotics. While such drug combinations are crucially important for the treatment of infections, bacteria are getting more and more resistant to all available antibiotics. To use available antibiotics more efficiently, and identify any so far unexploited weaknesses, bacterial responses to different drugs and their combinations need to be understood in detail. 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.

Career

since 2010 Assistant Professor, IST Austria
2006–2010 Postdoc, Department of Systems Biology, Harvard Medical School, Boston, USA
2005–2006 Postdoc, Max Planck Institute for the Physics of Complex Systems, Dresden, Germany
2005 Guest Scientist, University of Tokyo, Japan
2005 PhD, Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Selected Distinctions

since 2013 HFSP Program Grant
since 2011 Member of the Young Academy ("Junge Akademie") at the German National Academy of Sciences Leopoldina and the Berlin-Brandenburg Academy of Sciences and Humanities
2007–2009 Feodor Lynen Fellowship, Alexander von Humboldt Foundation
2005 REES Fellowship, Japan International Science & Technology Exchange Center
2000–2005 Student and PhD Fellowships, German National Scholarship Foundation



Green Fluorescent Protein in bacteria (above) and mouse embryos (bottom, image courtesy N. Plachta).

Team Andreas Angermayr (postdoc), Veronika Bierbaum (ISTFELLOW postdoc), Marjon de Vos (postdoc), Marta Dravecka (PhD student), Bor Kavcic (PhD student), Martin Lukacisin (PhD student), Karin Mitosch (PhD student), Qin Qi (postdoc), Julia Tischler (postdoc), Marcin Zagórski (ISTFELLOW postdoc)

Krishnendu Chatterjee

Computer-Aided Verification, Game Theory

Current Projects

Quantitative verification | Stochastic game theory | Modern graph algorithms for verification problems | Evolutionary game theory

Selected Publications

Brazdil T, Chatterjee K, Forejt V, Kucera A. 2013. Trading Performance for Stability in Markov Decision Processes. Proc. of LICS. 331-340.

Chatterjee K, Doyen L. 2012. Partial-Observation Stochastic Games: How to Win when Belief Fails. Proc. of LICS. 175-184.

Chatterjee K, Henzinger M. 2014. Efficient and Dynamic Algorithms for Alternating Büchi Games and Maximal End-Component Decomposition. J ACM. 61(3):15.

Life is a game – at least in theory. Game theory has implications for the verification of correctness of computer hardware and software, but also in biological applications, such as evolutionary game theory. The Chatterjee group works on the theoretical foundations of game theory, addressing central questions in computer science.

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 algorithmic analysis of various forms of games played on graphs. This broad framework allows effective analysis of many important questions of computer science and helps in the development of software systems. The Chatterjee group works on theoretical aspects for the better understanding of games and develops new algorithms, presenting the theoretical foundations for the formal verification of systems.

Career

since 2014 Professor, IST Austria
2009–2014 Assistant Professor, IST Austria
2008–2009 Postdoc, University of California, Santa Cruz, USA
2007 PhD, University of California, Berkeley, USA

Selected Distinctions

2011 Microsoft Research Faculty Fellowship
2011 ERC Starting Grant
2008 Ackerman Award, best thesis worldwide in Computer Science Logic
2007 David J. Sakrison Prize, best thesis in EECS, University of California, Berkeley, USA
2001 President of India Gold Medal, best IIT student of the year

Team Martin Chmelik (PhD student), Ventsislav Chonev (postdoc), Hongfei Fu (postdoc), Anchit Gupta (scientific intern), Christian Hilbe (ISTFELLOW postdoc), Rasmus Ibsen-Jensen (postdoc), Jan Kretínský (joint ISTFELLOW postdoc with Henzinger group), Samarth Mishra (scientific intern), Petr Novotny (ISTFELLOW postdoc), Vineet Pandey (scientific intern), Andreas Pavlogiannis (PhD student), Johannes Reiter (PhD student), Josef Tkadlec (PhD student)

Sylvia Cremer

Fighting Disease as a Collective: Social Immunity in Ants

Current Projects

Cooperative antiparasite behaviours in ant societies | Social interaction networks & epidemiology | Social vaccination | Host-parasite coevolution

Selected Publications

Theis FJ, Ugelvig LV, Marr C, Cremer S. 2015. Opposing effects of allogrooming on disease transmission in ant societies. Philosophical Transactions of the Royal Society B: Biological Sciences. Theme issue: Sociality, Health and Fitness Nexus. 370:20140108.

Konrad M, Grasse AV, Tragust S, Cremer S. 2015. Anti-pathogen protection versus survival costs mediated by an ectosymbiont in an ant host. Proceedings of the Royal Society B: Biological Sciences. 282: 20141976.

Novak S, Cremer S. 2015. Fungal disease dynamics in insect societies: optimal killing rates and the ambivalent effect of high social interaction rates. Journal of Theoretical Biology. 372: 54-56.

Social insects fight disease together as a collective. They perform sophisticated health care towards pathogen-exposed group members, comprising cleaning behavior and usage of antimicrobials. Sylvia Cremer's group lies at the interface of behavioral ecology and evolutionary immunology, and uses ants as a model system for disease management and epidemiology in societies.

Social insects like ants live together in dense and highly interactive colonies, facing a high risk of disease transmission among group members. Disease outbreaks are, however, kept in check as social insects have evolved collective anti-pathogen defenses, thereby complementing the individual immunity of colony members by additional "social immunity".

The Cremer group studies all aspects of collective immune defenses: (1) joint or mutual expression of health care behaviors, (2) the use of antimicrobial compounds, such as e.g. their formic-acid rich poison, and (3) the social interaction network of colony members, which forms the basis of disease transmission throughout the colony. Experimental work is performed to observe the behavioral changes realized by the ants upon pathogen threat. In collaboration with theoreticians, epidemiological modeling is used to assess whether the observed behaviors represent adaptive changes that limit disease spread through the colony.

Career

since 2015 Professor, IST Austria
2010–2015 Assistant Professor, IST Austria
2010 Habilitation, University of Regensburg, Germany
2006–2010 Group Leader, University of Regensburg, Germany
2006 Junior Fellow, Institute of Advanced Studies, Berlin, Germany
2002–2006 Postdoc, University of Copenhagen, Denmark
2002 PhD, University of Regensburg, Germany

Selected Distinctions

2015 Elisabeth Lutz Prize by the Austria Academy of Sciences (ÖAW)
2013 Walther Arndt Prize of the German Zoological Society
2012 Research Award Lower Austria: Anerkennungspreis des Landes Niederösterreich
2011 Elected Member of the *Junge Kurie* (Young Curia of the Austrian Academy of Sciences, ÖAW)
2009 ERC Starting Grant
2008 Elected Member of the Junge Akademie (Young Academy of the National German Academy of Sciences Leopoldina and BBAW); Alumna since 2013
2006 Junior Fellow at the Institute of Advanced Studies, Berlin, Germany

Brood care in ants
Photo (c) Chris Pull

Team Marko Bracic (scientific intern), Ruth Carter (scientific intern), Barbara Casillas Perez (PhD student), Biplabendu Das (ISTern student), Thomas Eder (co-supervised PhD student), Leila El Masri (ISTFELLOW postdoc), Eva Flechl (laboratory technician), Matthias Fürst (postdoc), Anna Grasse (senior laboratory technician), Matthias Konrad (postdoc), Ana Korsa (scientific intern), Barbara Leyrer (laboratory technician), Sina Metzler (scientific intern), Barbara Milutinovic (ISTFELLOW postdoc), Filip Naiser (scientific intern), Christopher Pull (PhD student), Miriam Stock (postdoc), Line Ugelvig (postdoc), Florian Wiesenhofer (laboratory technician)

Jozsef Csicsvari

Systems Neuroscience

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

Selected Publications

Dupret D, O'Neill J, Csicsvari J. 2013. Dynamic reconfiguration of hippocampal interneuron circuits during spatial learning. Neuron. 78:166-180.

Dupret D, O'Neill J, Pleydell-Bouverie B, Csicsvari J. 2010. The reorganization and reactivation of hippocampal maps predict spatial memory performance. Nature Neuroscience. 13(8), 995-1002.

O'Neill J, Senior TJ, Allen K, Huxter JR, Csicsvari J. 2008. Reactivation of experience-dependent cell assembly patterns in the hippocampus. Nature Neuroscience. 11(2), 209-215.

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.

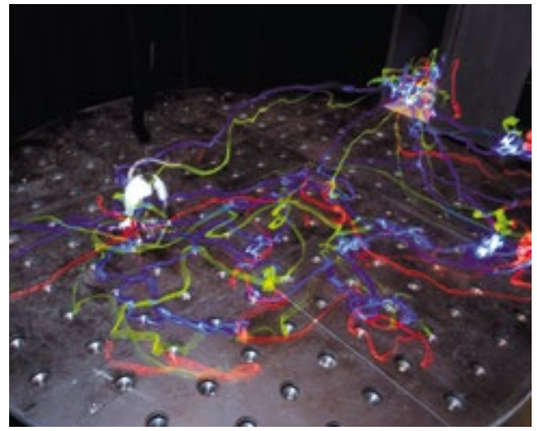
During learning, memory traces are processed and encoded in neuronal circuits and consolidated for later recall. The Csicsvari group focuses on the hippocampus, a brain area known to be important for spatial memory formation, and aims to understand how learning leads to memory formation. The group seeks 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 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 storing spatial information.

Career

since 2011 Professor, IST Austria
2008–2011 MRC Senior Scientist (tenured), MRC Anatomical Neuropharmacology Unit, University of Oxford, UK
2003–2008 MRC Senior Scientist (tenure-track), MRC Anatomical Neuropharmacology Unit, University of Oxford, UK
2001–2002 Research Associate, Center for Behavioral and Molecular Neuroscience, Rutgers University, New Brunswick, USA
1999–2001 Postdoctoral Fellow, Center for Behavioral and Molecular Neuroscience, Rutgers University, New Brunswick, USA
1993–1999 Graduate Assistant, Center for Behavioral and Molecular Neuroscience, Rutgers University, New Brunswick, USA
1999 PhD, Rutgers University, New Brunswick, USA

Selected Distinctions

2011 ERC Starting Grant
2010 Title of Ad Hominem Professor in Neuroscience at the University of Oxford



Ultra slow exposure image of a learning experiment on the "cheeseboard" maze.

Team Peter Baracskay (postdoc), Karel Blahna (postdoc), Charlotte Boccara (postdoc), Desiree Dickerson (postdoc), Igor Gridchyn (PhD student), Vivien Heiner (scientific intern), Karola Käfer (PhD student), Krisztián Kovács (ISTFELLOW postdoc), Michele Nardin (scientific intern), Joseph O'Neill (postdoc), Frances Quevenco (scientific intern), Dámaris Rangel Guerrero (PhD student), Philipp Schönenberger (postdoc), Federico Stella (postdoc), Jago Wallenschus (laboratory technician), Haibing Xu (PhD student)

Herbert Edelsbrunner

Algorithms, Computational Geometry & Topology

Current Projects

Applied computational algebraic topology | Topological dynamical systems

Selected Publications

Edelsbrunner H, Harer JL. 2010. Computational Topology. An Introduction. American Mathematical Society, Providence, Rhode Island.

Edelsbrunner H. 2001. Geometry and topology for mesh generation. Cambridge University Press, Cambridge, England.

Edelsbrunner H. 1987. Algorithms in combinatorial geometry. Springer-Verlag, Heidelberg, Germany.

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

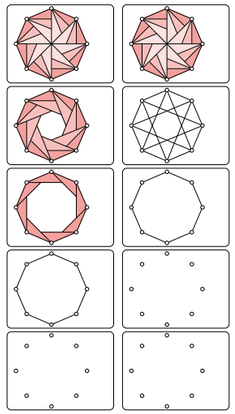
Topology, the study of shapes and how they are connected and deform, can be used to address a number of questions in applications as diverse as dynamical systems, scientific visualization, structural molecular biology, systems biology, geometry processing, medical imaging, and orthodontics. The common 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.

Career

since 2009	Professor, IST Austria
2004–2012	Professor for Mathematics, Duke University, Durham, USA
1999–2012	Arts and Sciences Professor for Computer Science, Duke University, Durham, USA
1996–2013	Founder, Principal, and Director, Raindrop Geomagic
1985–1999	Assistant, Associate, and Full Professor, University of Illinois, Urbana-Champaign, USA
1981–1985	Assistant, Graz University of Technology, Austria
1982	PhD, Graz University of Technology, Austria

Selected Distinctions

	ISI Highly Cited Researcher
2014	Member, Austrian Academy of Sciences
2012	Corresponding Member of the Austrian Academy of Sciences
2009	Member, Academia Europaea
2008	Member, German Academy of Sciences Leopoldina
2006	Honorary Doctorate, Graz University of Technology
2005	Member, American Academy of Arts and Sciences
1991	Alan T. Waterman Award, National Science Foundation



The multi-scale image of connections in a sampled dynamical system.

Team Arseniy Akopyan (ISTFELLOW postdoc), Gabriele Beltramo (scientific intern), Stefan Huber (postdoc), Mabel Iglesias Ham (PhD student), Mirko Klukas (postdoc), Zuzana Masárová (PhD student), Anton Nikitenko (PhD student), Salman Parsa (postdoc), Florian Pausinger (PhD student), Pawel Pilarczyk (postdoc), Olga Symonova (postdoc), Ziga Virk (postdoc), Hubert Wagner (postdoc)

László Erdős

Mathematics of Disordered Quantum Systems and Matrices

Current Projects

Self-consistent resolvent equation and application in random matrices | Next order correction in the form factor for Wigner matrices | Local spectral universality for random band matrices | Spectral statistics of random matrices with correlated entries | Quantum spin glasses

Selected Publications

Bourgade P, Erdős L, Yau H-T. 2014. Edge universality of beta ensembles. Commun. Math. Phys. 332 no. 1, 261-354.

Erdős L, Yau H-T. 2012. Universality of local spectral statistics of random matrices. Bull. Amer. Math. Soc. 49, no.3, 377-414.

Erdős L, Yau H-T, Yin J. 2012. Rigidity of Eigenvalues of Generalized Wigner Matrices. Adv. Math. 229, no. 3, 1435-1515.

Wigner's vision that a simple random matrix can replace a multi-dimensional quantum model when calculating nuclear energy levels laid the groundwork for random matrix theory. Whether a random matrix underlies also other physical systems is the central question pursued by the Erdős group.

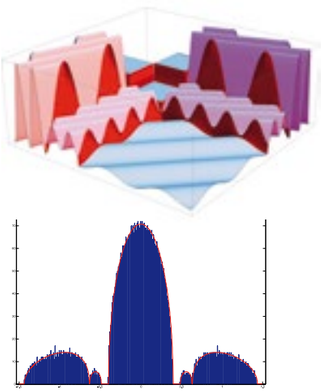
Surprisingly, a large matrix filled at random allowed for calculating energy levels of nuclei in heavy atoms. With this substitution, Eugene Wigner laid the basis for random matrix theory (RMT), which is now used to find patterns in huge amounts of data, even in stock market trends. Although experimental data leave no doubt that Wigner's substitution is correct, the reason for why it works is still not fully understood. In one part of their research, László Erdős and his group ask whether this reduction is also justified with mathematical rigor. Extending RMT to other physical systems and looking for universality in them, the group intends to move the simplified random matrix model back towards the original object of research from physics. At the same time, they ask whether the random matrix model is also underlying other physical models, and whether the "intermediate" approaches they develop may be used to mathematically solve other long-standing questions in physics. The mathematical ideas and tools developed as part of the Erdős group's work will extend RMT, and are likely to be used in its many applications, such as network analysis, information theory and other fields of physics.

Career

since 2013	Professor, IST Austria
2003–2013	Chair of Applied Mathematics (C4/W3), Ludwig-Maximilians University, Munich, Germany
1998–2003	Assistant, Associate, Full Professor, Georgia Institute of Technology, Atlanta, USA
1995–1998	Courant Instructor/Assistant Professor, Courant Institute, New York University, USA
1994–1995	Postdoc, ETH Zurich, Switzerland
1994	PhD in Mathematics, Princeton University, USA

Selected Distinctions

2015	Corresponding member, Austrian Academy of Sciences
2015	Member, Academia Europaea
2014	Invited Speaker, ICM
2013	ERC Advanced Grant
2007–2016	Participant of SFB TR12, Symmetries and Universality
1999–2005	NSF Grants
1993–1994	Alfred P. Sloan Foundation Dissertation Fellowship



Variance profile of an inhomogeneous random matrix H. (above) Eigenvalue distribution of H and its limiting density. (bottom)

Team Oskari Ajanki (postdoc), Johannes Alt (PhD student), Zhigang Bao (postdoc), Torben Krüger (postdoc), Christian Sadel (ISTFELLOW postdoc), Kevin Schnelli (postdoc)

Jiří Friml

Developmental and Cell Biology of Plants

Current Projects

Polar auxin transport | Cell polarity and polar targeting | Endocytosis and recycling

Selected Publications

Chen X, Grandont L, Li H, Hauschild R, Paque S, Abuzeineh A, Rakusová H, Benková E, Perrot-Rechenmann C, Friml J. 2014. Inhibition of cell expansion by rapid ABP1-mediated auxin effect on microtubules. Nature. 4;516(7529):90-93. Epub 2014 Nov 17.

Viaene T, Landberg K, Thelander M, Medvecka E, Pederson E, Feraru E, Cooper ED, Karimi M, Delwiche CF, Ljung K, Geisler M, Sundberg E, Friml J. 2014. Directional auxin transport mechanisms in early diverging land plants. Current Biology. Nov 24(23):2786-2791. Epub 2014 Nov 13.

Naramoto S, Otegui MS, Kutsuna N, de Rycke R, Dainobu T, Karampelias M, Fujimoto M, Feraru E, Miki D, Fukuda H, Nakano A, Friml J. 2014. Insights into the Localization and Function of the Membrane Trafficking Regulator GNOM ARF-GEF at the Golgi Apparatus in Arabidopsis. Plant Cell. 26(7):3062-3076.

While animals can move away if conditions turn harsh, plants are rooted in their environment. Plants have therefore become remarkably adaptable to different conditions. The Friml group investigates the mechanisms underlying their adaptability during plants' embryonic and postembryonic development.

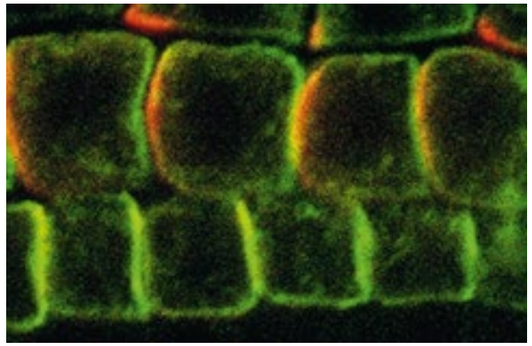
Plants and animals live different lives. While animals can react to conditions by changing their behavior, plants have acquired a highly adaptive development that allows them to respond to changes. Indevelopment, plants can do much more than animals, such as growing new organs. Many of plants' unique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

Career

since 2013 Professor, IST Austria
2007–2012 Full Professor, University of Ghent, Belgium
2006 Full Professor, University of Göttingen, Germany
2002–2005 Groupleader, Habilitation in Genetics, University of Tübingen, Germany
2002 PhD, Biochemistry, Masaryk University, Brno, Czech Republic
2000 PhD, Biology, University of Cologne, Germany

Selected Distinctions

2012 EMBO Gold Medal
2011 AAAS Fellow
2010 EMBO Member
2010 Körber European Science Award
2010 Olchemim Scientific Award
2005 Heinz Maier-Leibnitz Prize
2004 EMBO Young Investigator Award
2000 Max Planck Society Award: The Otto Hahn Medal



Polarity in Arabidopsis cells.

Team Mohamad Abbas (postdoc), Maciek Adamowski (PhD student), Xu Chen (postdoc), Matyas Fendrych (ISTFELLOW postdoc), Verena Freifrau von Wangenheim (scientific intern), Matous Glanc (scientific intern), Hongjiang Li (postdoc), Jaroslav Michalko (postdoc), Gergely Molnar (postdoc), Madhumitha Narasimhan (PhD student), Tomas Prat (PhD student), Yuliya Salanenka (postdoc), Sibu Simon (laboratory technician), Shutang Tan (ISTFELLOW postdoc), Petr Valosek (laboratory technician), Daniel von Wangenheim (ISTFELLOW postdoc), Saiko Yoshida (ISTFELLOW postdoc)

Călin Guet

Systems and Synthetic Biology of Genetic Networks

Current Projects

Information processing and evolution of complex promoters | Systems biology of the regulon | Single-cell biology and evolutionary dynamics of restriction-modification systems

Selected Publications

Guet CC, Gupta A, Henzinger TA, Mateescu M, Sezgin A. 2012. Delayed continuous-time Markov chains for genetic regulatory circuits. Lecture Notes in Computer Science CAV. 7358, 294-309.

Yazdi NH, Guet CC, Johnson RC, Marko JF. 2012. Variation of the folding and dynamics of the Escherichia coli chromosome with growth conditions. Molecular Microbiology. 86, 1318-1333.

Guet CC, Elowitz MB, Hsing WH, Leibler S. 2002. Combinatorial synthesis of genetic networks. Science. 296(5572), 1466-1470.

Networking is important on any level and in any environment – even 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.

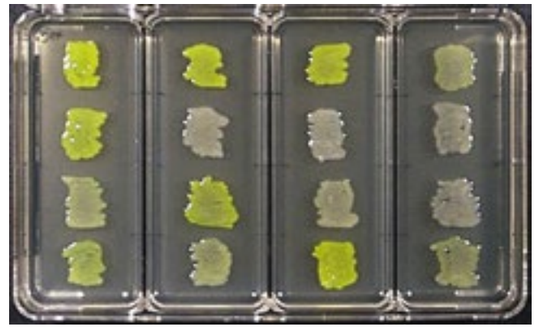
Genes and proteins constitute themselves into bio-molecular networks in cells. These genetic networks are engaged in a constant process of decision-making and computation over time scales of a few seconds to the time it takes the organism to replicate, and even beyond. By studying existing networks and 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 covers information processing at complex bacterial promoters, which integrate signals and regulate the expression of genes accordingly. The group uses a variety of classical and modern experimental techniques which together enable them to construct any imaginable network in living bacteria and thus to study the network dynamics at the single-cell level, which is the relevant scale of experimental interrogation.

Career

since 2011 Assistant Professor, IST Austria
2009 Postdoc, Harvard University, Cambridge, USA
2005 Postdoc, The University of Chicago, USA
2004 PhD, Princeton University, USA

Selected Distinctions

2011 HFSP Research Grant
2005 Yen Fellow, The University of Chicago, USA
1997 Sigma XI Membership



Colonies of Escherichia coli performing Boolean logic computations with two chemical inputs and green fluorescent protein (GFP) as the output state.

Team Tobias Bergmiller (postdoc), Remy Chait (postdoc), Ana Dolinar (scientific intern), Moritz Lang (joint ISTFELLOW postdoc with Tkačik group), Anna Nagy-Staron (postdoc), Tatjana Petrov (joint postdoc with Henzinger group), Maros Pleska (PhD student), Magdalena Steinrück (PhD student), Isabella Tomanek (joint PhD student with Bollback group)

Carl-Philipp Heisenberg

Morphogenesis in Development

Current Projects

Cell adhesion | Actomyosin contraction | Cell and tissue morphogenesis | Cell polarization and migration

Selected Publications

Ruprecht V, Wieser S, Callan-Jones A, Smutny M, Morita H, Sako K, Barone V, Ritsch-Marte M, Sixt M, Voituriez R, Heisenberg CP. Cortical contractility triggers a stochastic switch to fast amoeboid cell motility. Cell. 2015 Feb 12;160(4):673-85.

Behrndt M, Salbreux G, Campinho P, Hauschild R, Oswald F, Roensch J, Grill S, Heisenberg CP. 2012. Forces driving epithelial spreading in zebrafish gastrulation. Science. 338(6104), 257-260.

Maitre JL, Berthoumieux H, Krens SF, Salbreux G, Juelicher F, Paluch E, Heisenberg CP. 2012. Adhesion functions in cell sorting by mechanically coupling the cortices of adhering cells. Science. 338(6104), 253-256.

The most elaborate shapes of multicellular organisms – the elephant's trunk, the orchid blossom, the lobster's claw – all start off from a simple 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.

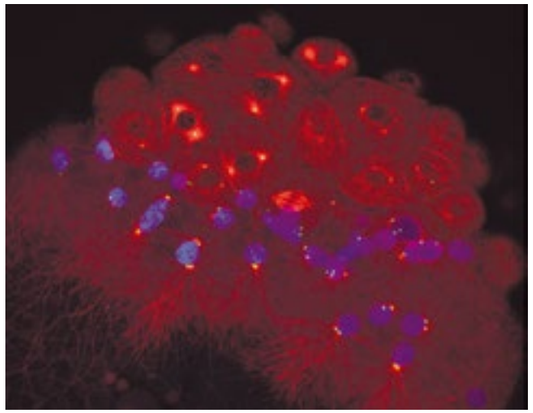
The Heisenberg group studies the molecular and cellular mechanisms by which vertebrate embryos take shape. To gain insights into critical processes in morphogenesis, the group focuses on gastrulation movements in zebrafish. Gastrulation is a highly conserved process in which a seemingly unstructured 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, bio-chemical 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.

Career

since 2010	Professor, IST Austria
2001–2010	Group Leader, Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany
1997–2000	Postdoc, University College London, UK
1996	PhD, Max Planck Institute of Developmental Biology, Tübingen, Germany

Selected Distinctions

2015	Member of the German National Academy of Sciences (Leopoldina)
2000	Emmy Noether Junior Professorship
1998	Marie Curie Postdoctoral Fellowship
1997	EMBO Long Term Fellowship



Zebrafish embryo at the onset of gastrulation, stained for nuclei (blue), microtubules (red) and microtubule organizing centers (white).

Team Vanessa Barone (PhD student), Silvia Caballero Mancebo (joint PhD student with Hof group), Daniel Capek (PhD student), Benoit Godard (postdoc), Karla Huljev (joint PhD student with the Benková group), Roland Kardos (ISTFELLOW postdoc), Gabriel Krens (postdoc), Hitoshi Morita (postdoc), Kornelija Pranjic-Ferscha (technician), Verena Ruprecht (postdoc), Keisuke Sako (postdoc), Philipp Schmalhorst (postdoc), Cornelia Schwayer (PhD student), Shayan Shami-Pour (joint PhD student with Hof group), Mateusz Sikora (postdoc), Jana Slovakova (ISTFELLOW postdoc), Michael Smutny (postdoc), Peng Xia (postdoc)

Thomas A. Henzinger

Design and Analysis of Concurrent and Embedded Systems

Current Projects

Analysis and synthesis of concurrent software | Quantitative modeling and verification of reactive systems | Predictability and robustness for real-time and embedded systems | Model checking biochemical reaction networks

Selected Publications

Gupta A, Henzinger TA, Radhakrishna A, Samanta R, Tarrach T. 2015. Succinct representation of concurrent trace sets. Proc. Symp. Principles of Programming Languages (POPL), ACM Press.

Chatterjee K, Henzinger TA, Otop J. 2015. Nested weighted automata. Proc. Symp. Logic in Computer Science (LICS), IEEE Computer Society Press.

Cerny P, Clarke EM, Henzinger TA, Radhakrishna A, Ryzhyk L, Samanta R, Tarrach T. 2015. From nonpreemptive to preemptive scheduling using synchronization synthesis. Proc. Conf. Computer-Aided Verification (CAV), Lecture Notes in Computer Science, Springer.

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 show up 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 the reliability of software in concurrent and embedded systems.

Career

since 2009	Professor, IST Austria
2004–2009	Professor, EPFL, Lausanne, Switzerland
1999–2000	Director, Max Planck Institute for Computer Science, Saarbruecken, Germany
1998–2004	Professor, University of California, Berkeley, USA
1997–1998	Associate Professor, University of California, Berkeley, USA
1996–1997	Assistant Professor, University of California, Berkeley, USA
1992–1995	Assistant Professor, Cornell University, Ithaca, USA
1991	Postdoc, University Joseph Fourier, Grenoble, France
1991	PhD, Stanford University, Palo Alto, USA

Selected Distinctions

ISI Highly Cited Researcher

2015	Royal Society Milner Award
2015	EATCS Fellow
2015	Honorary Doctorate, Masaryk University, Brno
2014	Most Influential 2004 POPL Paper Award
2013	AAAS Fellow
2012	Wittgenstein Award
2012	Honorary Doctorate, University Joseph Fourier, Grenoble, France
2012	Logic in Computer Science Test-of-Time Award
2011	Member, Austrian Academy of Sciences
2011	ACM SIGSOFT Impact Paper Award
2010	ERC Advanced Grant
2006	ACM Fellow
2006	IEEE Fellow
2006	Member, Academia Europaea
2005	Member, German Academy of Sciences Leopoldina
1995	ONR Young Investigator Award
1995	NSF Faculty Early Career Development Award

Team Sergiy Bogomolov (postdoc), Przemyslaw Daca (PhD student), Jessica Davies (postdoc), Charmi Dedhia (scientific intern), Mirco Giacobbe (PhD student), Hui Kong (postdoc), Bernhard Kragl (PhD student), Andrey Kupriyanov (postdoc), Jan Otop (postdoc), Pradyot Prakash (scientific intern), Jakob Ruess (joint ISTFELLOW postdoc with Tkačik group), Roopsha Samanta (postdoc), Thorsten Tarrach (PhD student)

Simon Hippenmeyer

Genetic Dissection of Cerebral Cortex Development

The human brain is a sophisticated network of billions of interconnected neurons. Simon Hippenmeyer's group exploits genetic techniques in the mouse to better understand how the brain's precise connectivity emerges during development.

Our brains are composed of a vast number of neurons, and can function only because of the intricate connections formed between them. In order to better understand how the cerebral cortex accounts for behavior and cognitive activity, the Hippenmeyer group maps the assembly of the neuronal architecture during cortex development in the mouse. The group uses multidisciplinary approaches, including the genetic MADM (Mosaic Analysis with Double Markers) technique, to trace how individual neurons build up the cortex successively during development. Looking at the brain is similar to looking at a forest: While looking at a forest from afar, it is difficult to make out the trimming of a single branch of an individual tree. However, when a tree stands alone in a field, it is easy to observe the snip of even the finest branch. The MADM technique allows the Hippenmeyer group to visualize small groups of neurons, and even individual neurons, at the single cell level and manipulate them at the same time. This unparalleled method allows researchers to navigate through the dense network of neurons in the brain to exactly follow individual neurons and their fine branches. Simon Hippenmeyer's group determines the molecular mechanisms regulating neurogenesis, lineage and neuronal migration; and analyzes the cellular pathology associated with genes that when mutated in human cause neurodevelopmental disorders. In a second line of research the Hippenmeyer group analyzes the role of genomic imprinting (an epigenetic phenomenon) in neuronal circuit assembly.

Current Projects

Determination of neuronal lineages by clonal analysis | Dissection of molecular mechanisms of cortical neuron migration | Probing of genomic imprinting in cortex development

Selected Publications

Gao P, Postiglione MP, Krieger TG, Hernandez L, Wang C, Han Z, Streicher C, Papusheva E, Insolera R, Chugh K, Kodish O, Huang K, Simons BD, Luo L, Hippenmeyer S, Shi SH. 2014. Deterministic Progenitor Behavior and Unitary Production of Neurons in the Neocortex. Cell 159, 775-788.

Hippenmeyer S, Johnson RL, Luo L. 2013. Mosaic Analysis with Double Markers Reveals Cell Type Specific Paternal Dominance. Cell Reports 3, 960-967.

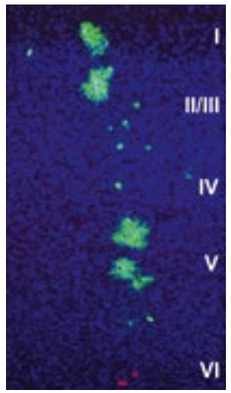
Hippenmeyer S, Young YH, Moon HM, Miyamichi K, Zong H, Wynshaw BA, Luo L. 2010. Genetic Mosaic Dissection of Lis1 and Ndel1 in Neuronal Migration. Neuron 68 (4), 695-709.

Career

since 2012 Assistant Professor, IST Austria
2011–2012 Research Associate, Stanford University, Palo Alto, USA
2006–2011 Postdoctoral Fellow, Stanford University, Palo Alto, USA
2004–2006 Postdoctoral Associate, University of Basel and Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland
2004 PhD, University of Basel and Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland

Selected Distinctions

2014 HFSP Program Grant
2013 Marie Curie Career Integration Grant
2009–2011 Fellowship for Advanced Researchers (Swiss National Science Foundation; Bern, Switzerland)
2007–2009 HFSP Long-Term Fellowship
2006 EMBO Long-Term Fellowship
2005 Faculty Prize 2005 for the best PhD thesis of the year 2004 (Faculty of Natural Sciences, University of Basel, Switzerland)
2005 Edmond H. Fischer Prize 2005 (Friedrich Miescher Institute or Biomedical Research, Basel, Switzerland)



MADM-labeled clonally-related neurons and glia cells distributed across the six layers in the cerebral cortex.

Team Robert Beattie (postdoc), Elaine Fisher (scientific intern), Theresa König (scientific intern), Susanne Laukoter (PhD student), Florian Pauler (senior laboratory technician), Maria Postiglione (postdoc), Justine Renno (PhD student), Julio Rodarte (laboratory technician), Johanna Sonntag (laboratory technician), Carmen Streicher (laboratory technician)

Björn Hof

Nonlinear Dynamics and Turbulence

Turbulent fluid motion 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 aregoverned by complex chaotic dynamics. Fluid turbulence – seen in fluidssuch as water or air – is the most common form of disorder in nature. Despite its ubiquity, insights into the nature of turbulence are very limited. To gain a fundamental understanding of turbulence, the Hof group investigates turbulence when it first arises from smooth, laminar flow. The group combines detailed laboratory experiments with highly resolved computer simulations, and applies methods from nonlinear dynamics and statistical physics. This enables the Hof group to decipher key aspects of the transition from smooth to turbulent flow, and identify universal features shared with disordered systems in other areas of physics. Some of the Hof group's insights can be directly applied to control turbulent flow, and the group actively develops such methods.

Current Projects

Transition from laminar to turbulent flow | Dynamics of complex fluids | Control of fully turbulent flows | Locomotion of plankton larvae

Selected Publications

Hof B, de Lozar A, Avila M, Tu X, Schneider TM. 2010. Eliminating turbulence in spatially intermittent flows. Science. 327, 1491-1494.

Avila K, Moxey D, de Lozar A, Avila M, Barkley D, Hof B. 2011. The onset of turbulence in pipe flow. Science. 333, 192-196.

Barkley D, Song B, Vasudevan M, Lemoult G, Avila M, Hof B. 2015. The rise of fully turbulent flow. Nature. 526, 550-553.

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, UK
2003–2005 Research Associate, Delft University of Technology, The Netherlands
2001 PhD, University of Manchester, UK

Selected Distinctions

2012 ERC Consolidator Grant
2011 Dr. Meyer Struckmann Science Price
2005 RCUK Fellowship

Team Sebastian Altmeyer (postdoc), Nazmi Budanur (postdoc), George Choueiri (ISTFELLOW postdoc), Sebastian Floss (scientific intern), Shreyas Jalikop (postdoc), Jakob Kühnen (postdoc), Grégoire Lemoult (postdoc), Jose Lopez Alonso (postdoc), Xingyu Ma (postdoc), Philipp Maier (technician), Chaitanya Paranjape (PhD student), Jan Schlüter (scientific intern), Michael Schwegel (scientific intern), Shayan Shamipour (joint PhD student with Heisenberg group), Mukund Vasudevan (postdoc), Sascha Warnecke (scientific intern), Duo Xu (postdoc)

Harald Janovjak

Synthetic Physiology

Current Projects

Synthetic control of receptors and signaling pathways | Remote restoration of cell and animal behavior

Selected Publications

Grusch M, Schelch K, Riedler R, Reichhart E, Differ C, Berger W, Ingles-Prieto Á, Janovjak H. 2014. Spatio temporally precise activation of engineered receptor tyrosine kinases by light. EMBO Journal. 33:1713-1726.

Ingles-Prieto Á, Reichhart E, Muellner MK, Nowak M, Nijman SM, Grusch M, Janovjak H. 2015. Light-assisted small molecule screening against protein kinases. Nature Chemical Biology. 11, 952-954.

Hühner J, Ingles-Prieto Á, Neusüss C, Lämmerhofer M, Janovjak H. Quantification of riboflavin, flavin mononucleotide, and flavin adenine dinucleotide in mammalian model cells by CE with LED-induced fluorescence detection. Electrophoresis. 36, 518-525.

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

Receptors on the surface of cells are the antennas that receive chemical signals and pass them on to the inside of the cell, causing specific and tightly controlled responses of multifaceted signaling pathways. The Janovjak group seeks to understand cellular signals and takes a unique synthetic biology approach to actively manipulate this process. Receptors are engineered to respond to new physical stimuli, such as light, rather than to their native chemical signals. The artificial stimuli are then used to study circuits and networks by activating or inactivating them at any given point and to synthetically create or restore aberrant signaling in health and disease.

Career

since 2011 Assistant Professor, IST Austria
2010–2011 Postdoc, University of Munich, Germany
2006–2010 Postdoc, University of California, Berkeley, USA
2005 PhD, University of Dresden, Germany

Selected Distinctions

2011 HFSP Young Investigator Grant
2011 EU FP7 Career Integration Grant
2007–2009 EMBO Long-term Fellowship
2005 PhD with highest honors (summa cum laude)

Using optogenetics to manipulate the cell signaling machinery.

Team Cathrin Heidsiek (scientific intern), Álvaro Ingles Prieto (postdoc), Kristian Kolev (laboratory technician), Carina Kraupa (scientific intern), Catherine Mckenzie (PhD student), Maurizio Morri (PhD student), Bernhard Ransmayr (scientific intern), Eva Reichhart (PhD student), Laura Rodriguez Hernandez (ISTFELLOW postdoc), Inmaculada Sanchez Romero (postdoc), Miroslava Spanova (laboratory technician), Alexandra-Madelaine Tichy (scientific intern)

Peter Jonas

Synaptic Communication in Hippocampal Microcircuits

Current Projects

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

Selected Publications

Hu H, Jonas P. 2014. A supercritical density of Na^+ channels ensures fast signaling in GABAergic interneuron axons. Nature Neuroscience. 17, 686-693.

Vyleta NP, Jonas P. 2014. Loose coupling between Ca^{2+} channels and release sensors at a plastic hippocampal synapse. Science. 343, 665-670.

Pernía-Andrade A, Jonas P. 2013. Theta-gamma modulated synaptic currents in hippocampal granule cells in vivo define a mechanism for network oscillations. Neuron. 81, 140-152.

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.

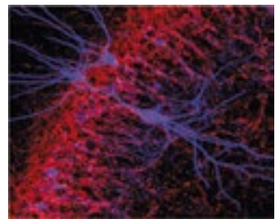
Understanding the function of neuronal microcircuits is one of the major challenges of life science in the 21st century. The human brain is comprised of approximately 10 billion neurons, which communicate with each other at a huge number of synapses, specialized sites of contact between neurons. Broadly, synapses in the brain fall into two categories: excitatory synapses releasing the transmitter glutamate and inhibitory synapses releasing Gamma-Aminobutyric acid (GABA). The Jonas group seeks to quantitatively adress the mechanisms of synaptic signaling, using multiple-cell recording, subcellular patch-clamp techniques, Ca^{2+} 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.

Career

since 2010 Professor, IST Austria
1995–2010 Professor & Department Head, University of Freiburg, Germany
1994–1995 Associate Professor, Technical University of Munich, Germany
1990–1994 Research Assistant, Max Planck Institute for Medical Research, Heidelberg, Germany
1988–1989 Postdoc, University of Giessen, Germany
1987 PhD, University of Giessen, Germany

Selected Distinctions

2015 Member, Academia Europaea
2011 ERC Advanced Grant
2009 Adolf-Fick-Award, Physicomedical Society, Würzburg, Germany
2008 Member, Academy of Sciences, Heidelberg, Germany
2007 Tsungming Tu Award, National Science Council Taiwan
2006 Szentagothai memorial lecture, University of California, Irvine, USA
2006 Gottfried Wilhelm Leibniz Award, German Research Foundation
2002 Member, German Academy of Sciences Leopoldina
1998–2001 Human Frontiers Science Program Organization Grant
1998 Max-Planck Research Award
1997 Medinfar European Prize in Physiology, Portugal
1994 Heinz Maier Leibnitz Award, German Ministry for Education and Science
1992 Heisenberg Fellowship, German Research Foundation



Presynaptic hippocampal basket cell (lower right) and postsynaptic granule neurons (upper left).

Team Itaru Arai (postdoc), Carolina Borges Merjane (ISTFELLOW postdoc), Chong Chen (PhD student), Claudia Espinoza Martinez (PhD student), Jian Gan (postdoc), José Guzmán (postdoc), Hua Hu (postdoc), Eva Kramberger (administrative assistant), Florian Marr (senior laboratory technician), Rajiv Mishra (PhD student), Alejandro Pernia-Andrade (postdoc), Sarah Rosenthaler (laboratory technician), Giovanni Russo (postdoc), Alois Schlögl (software engineer), David Vandael (postdoc), Shih-Ming Weng (ISTFELLOW postdoc), Xiaomin Zhang (ISTFELLOW postdoc)

Anna Kicheva

Tissue Growth and Developmental Pattern Formation

Current Projects

Integration of opposing morphogen gradients | Morphogen control of tissue growth | Morphogen gradient formation

Selected Publications

Kicheva A, Bollenbach T, Ribeiro ACF, Pérez Valle H, Lovell-Badge RH, Episkopou V, Briscoe J. 2014. Coordination of progenitor specification and growth in mouse and chick spinal cord. Science. 345(6204), 1254927.

Wartlick O, Mumcu P, Kicheva A, Bittig T, Seum C, Jülicher F, González-Gaitán MA. 2011. Dynamics of Dpp signaling and proliferation control. Science. 331(6021), 1154-1159.

Kicheva A, Pantazis P, Bollenbach T, Kalaidzidis Y, Bittig T, Julicher F, Gonzalez-Gaitan M. 2007. Kinetics of morphogen gradient formation. Science. 315(5811), 521-525.

Individuals of the same species can differ widely in size, but their organs have reproducible proportions and patterns of cell types. This requires the coordination of tissue growth with the generation of diverse cell types during development. The Kicheva Group studies how this coordination is achieved in the vertebrate neural tube, the embryonic precursor of the spinal cord and brain.

The development of the neural tube is controlled by secreted signaling molecules, called morphogens. Morphogens control what type of neuron a neural progenitor cell will become. At the same time they control the growth of the tissue by influencing the decisions of cells to divide or exit the cell cycle. The goal of the Kicheva Group is to better understand how morphogen signaling levels are controlled and how cells interpret morphogen signaling to determine their cell fate and cell cycle progression.

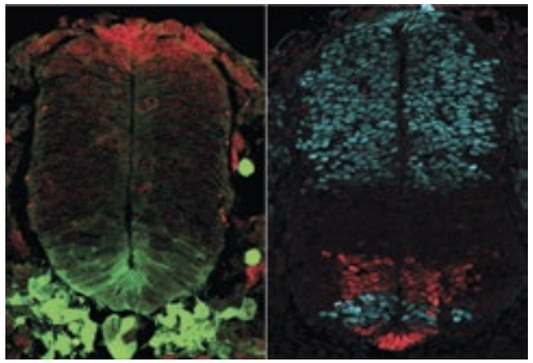
To address these questions, the group develops and uses quantitative experimental approaches, and works in close collaborations with physicists to relate experiments to theoretical frameworks. They are particularly interested in imaging the dynamics of morphogen signaling and growth in living tissues. Their work incorporates a range of models, from mouse and chick embryos to mouse embryonic stem cells.

Career

since 2015 Assistant professor, IST Austria
2008–2015 Postdoc, National Institute for Medical Research (The Francis Crick Institute), UK
2003–2008 PhD, University of Geneva, Biochemistry Dept. and Max Planck Institute of Cell Biology and Genetics, Dresden

Selected Distinctions

2015 ERC Starting Grant
2009 Marie-Curie Intra-European Fellowship
2008 FEBS Long Term Fellowship



The opposing Shh and BMP morphogen signaling gradients (left, green and red, resp.) and the striped pattern of target gene expression (right) in the mouse neural tube.

Team Martina Greunz (laboratory technician)

Vladimir Kolmogorov

Computer Vision and Discrete Optimization Algorithms

Current Projects

Inference in graphical models | Combinatorial optimization problems | Theory of discrete optimization

Selected Publications

Kolmogorov V, Krokhin A, Rolínek M. The Complexity of General-Valued CSPs. In IEEE Symposium on Foundations of Computer Science (FOCS). October 2015.

Gridchyn I, Kolmogorov V. 2013. Potts model, parametric maxflow and k-submodular functions. In IEEE International Conference on Computer Vision (ICCV), Sydney, Australia.

Kolmogorov V. 2009. Blossom V: A new implementation of a minimum cost perfect matching algorithm. Mathematical Programming Computation. 1(1), 43-67.

Stepping out onto 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.

Career

since 2014 Professor, IST Austria
2011–2014 Assistant Professor, IST Austria
2005–2011 Lecturer, University College London, UK
2003–2005 Assistant Researcher, Microsoft Research, Cambridge, UK
2003 PhD, Cornell University, Ithaca, USA

Selected Distinctions

2013 ERC Consolidator Grant
2012 Koenderink Prize at the European Conference on Computer Vision for fundamental contributions to computer vision
2007 Honorable mention, outstanding student paper award (to M. Pawan Kumar) at Neural Information Processing Systems Conference
2006–2011 The Royal Academy of Engineering/EPSRC Research Fellowship
2005 Best paper honorable mention award at IEEE Conference on Computer Vision and Pattern Recognition
2002 Best paper award at the European Conference on Computer Vision

Example of the "Grabcut" interactive image segmentation algorithm based on graph cuts, which has been incorporated in Microsoft Office 2010.

Team Alexandr Kazda (postdoc), Michal Rolinek (PhD student), Paul Swoboda (postdoc)

Christoph Lampert

Computer Vision and Machine Learning

Current Projects

Life-long visual learning | Transfer Learning | Image understanding with weak supervision | Structured prediction and learning

Selected Publications

Lampert CH, Nickisch H, Harmeling S. 2014. Attribute-based classification for zero-shot visual object categorization. IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI). 36(3), 453-465.

Pentina A, Lampert CH. 2014. A PAC-Bayesian bound for lifelong learning. In International Conference on Machine Learning (ICML). 991-999.

Lampert CH, Blaschko MB, Hofmann T.2009. Efficient subwindow search: A branch and bound framework for object localization. IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI). 31(12), 2129-2142.

Today's computer programs are "idiots savant": a software that is extremely good at a certain task, such as playing chess, is completely useless for most other tasks like searching a database, and vice versa. The Lampert group works on methods for computers to break out of this limitation by sharing information between different tasks.

Modern computer software adapts to its users, e.g. voice recognition software learns to understand its speaker better over time, and email programs learn which of all incoming emails are spam and should therefore be suppressed. However, this learning process happens independently for each task that the computer is meant to solve. The Lampert group develops and analyzes algorithms that allow computers to learn new tasks while making use of the knowledge acquired from previous tasks. A particular application area is automatic image understanding, whereby the goal of the software is to analyze the contents of a natural image and automatically answer question such as: What objects are visible in an image? Where are they located? How do they interact?

Career

since 2015 Professor, IST Austria
2010–2015 Assistant Professor, IST Austria
2007–2010 Senior Research Scientist, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
2004–2007 Senior Researcher, German Research Center for Artificial Intelligence, Kaiserslautern, Germany
2003 PhD, University of Bonn, Germany

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 Main Price, German Society for Pattern Recognition (DAGM)

Object recognition in natural images: learning-based computer vision techniques aim at detecting objects and describing them semantically.

Team Csaba Domokos (postdoc), Alexander Kolesnikov (PhD student), Dmitry Kondrashkin (scientific intern), Georg Martius (joint ISTFELLOW postdoc with Tkačik group), Eela Nagaraj (scientific intern), Anastasia Pentina (PhD student), Viktoriia Sharmanska (PhD student), Alexander Zimin (PhD student)

Mikhail Lemeshko

Theoretical Atomic, Molecular, and Optical Physics

Current Projects

Studying open quantum systems and understanding how dissipation acts at the microscopic scale | Many-body physics of ultracold quantum gases | Developing techniques to manipulate atoms, molecules, and interactions between them with electromagnetic fields

Selected Publications

Schmidt R, Lemeshko M. 2015. Rotation of quantum impurities in the presence of a many-body environment. Phys. Rev. Lett. 114, 203001.

Lemeshko M, Weimer H. 2013. Dissipative binding of atoms by non-conservative forces. Nature Communications. 4, 2230.

Lemeshko M, Krems RV, Weimer H. 2012. Non-adiabatic preparation of spin crystals with ultracold polar molecules. Phys. Rev. Lett. 109, 035301.

The whole is greater than the sum of its parts. Aristotle's saying also holds true in most systems studied by physics, chemistry, and biology. Mikhail Lemeshko investigates how phenomena arise when more and more parts are added to make the whole.

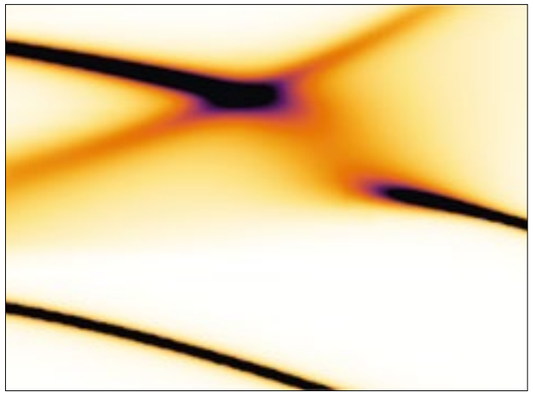
Many physical, chemical, and biological systems show the property called emergence: from the social behavior of insects, to the dynamics of internet traffic, to the stock market trends – all of these phenomena can hardly be explained by just looking at the individual parts that they are made up of. The same applies to the physical systems: looking at a single atom of a given kind, it is hard to predict whether the resulting bulk material will be solid, gaseous or liquid, crystalline or amorphous, magnetic or non-magnetic, conductive or insulating. Mikhail Lemeshko studies the emergent behavior in quantum systems composed of atoms and molecules. Usually, these questions are approached "top-down": by cutting a system into ever smaller parts and studying those. Lemeshko, however, follows a "bottom-up" approach: In some quantum systems, such as quantum gases or ultracold atoms, researchers can fully control individual atoms and molecules. By manipulating these parts, researchers can study how phenomena emerge with an increasing number of particles. Mikhail Lemeshko focuses on atomic, molecular, and optical physics. He seeks to theoretically study and answer questions such as: How many particles are sufficient for a given property to emerge? How does dissipation act on quantum systems? How can the novel phenomena be observed in modern experiments? And what are the practical applications of controllable quantum systems, such as artificial atoms?

Career

since 2014 Assistant Professor, IST Austria
2011–2014 ITAMP postdoctoral fellow, Harvard University, Cambridge, USA
2011 PhD in AMO physics, Fritz Haber Institute of Max Planck Society, Berlin
2007 MSc in Condensed Matter Physics, Southern Federal University Rostov, Russia

Selected Distinctions

2012 One of four finalists, worldwide Thesis Prize competition, AMO division of the American Physical Society (the only theory finalist)
2011 ITAMP Postdoctoral Fellowship



Fine structure appearing in the rotational spectrum of a molecule due to the interaction with a quantum many-body environment (Schmidt&Lemeshko, Phys. Rev. Lett. 114, 203001. 2015).

Team Rajat Agarwal (scientific intern), Clemens Jochum (scientific intern), Jan Kaczmarczyk (ISTFELLOW postdoc), Bikashkali Midya (ISTFELLOW postdoc), Laleh Safari (postdoc)

Martin Loose

Self-organization of the Cell

Current Projects

Identifying biochemical networks that determine intracellular organization | Describing capabilities of proteins to form dynamic large-scale structures | Explaining processes of evolutionary change in biochemical networks

Selected Publications

Loose M, Mitchison TJ. 2014. The bacterial cell division proteins ftsA and ftsZ self-organize into dynamic cytoskeletal patterns. Nature Cell Biology. 16(1), 38-46.

Loose M, Fischer-Friedrich E, Herold C, Kruse K, Schwille P. 2011. Min protein patterns emerge from rapid rebinding and membrane interaction of MinE. Nature Structural and Molecular Biology. 18(5), 577-583.

Loose M, Fischer-Friedrich E, Ries J, Kruse K, Schwille P. 2008. Spatial regulators for bacterial cell division self-organize into surface waves in vitro. Science. 320(5877), 789-792.

One of the most remarkable features of biological systems is their ability to self-organize in space and time. Although the individual players involved in this intracellular organization have been identified, the issue of how they act together to accomplish a specific function is not yet understood.

Even a relatively simple cell like Escherichia coli faces extremely complex and challenging tasks: for cell division, the E. coli cell first has to identify the location for the assembly of the cell division machinery, which then organizes a concerted invagination of a layered cell envelope while simultaneously remodeling its surrounding peptidoglycan layer. In recent years it has become increasingly clear that sophisticated and diverse mechanisms are involved in the spatiotemporal dynamics that allow for cell division, but we are only beginning to understand how the underlying biochemical network can achieve this task.

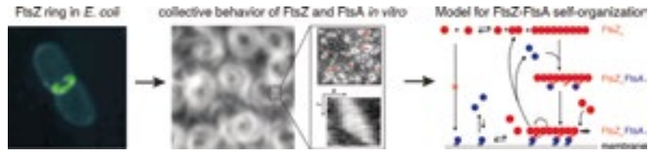
The research goal of the Loose group is to understand the mechanisms of intracellular self-organization by rebuilding cellular functions from purified components. Instead of looking at complex phenomena in an intact cell, they develop in vitro experiments recapitulating distinct cellular behavior. Their interdisciplinary approach combines biochemical reconstitution experiments with advanced fluorescence microscopy down to the single molecule level, biomimetic membrane systems, and micropatterning techniques. With their current work focused on protein systems from bacterial and eukaryotic cells, they aim at finding the general principles underlying protein self-organization.

Career

since 2015 Assistant Professor, IST Austria
2011–2014 Departmental fellow, Department of Systems Biology, Harvard Medical School, Boston, USA
2010–2011 Postdoc, TU Dresden and MPI-CBG, Dresden, Germany
2010 PhD, TU Dresden and MPI-CBG, Dresden, Germany

Selected Distinctions

2015 ERC Starting Grant
2012–2014 HSFP Long-Term fellowship
2011–2012 EMBO Long-Term fellowship
2010 Dr.-Walter-Seipp-Award for best dissertation at TU Dresden
2001–2009 Student and PhD Fellowship of the German National Scholarship Foundation (‘Studienstiftung des deutschen Volkes’)



In vitro reconstitution of minimal biochemical systems is a powerful approach to understand self-organized processes in the living cell. Left, in Escherichia coli, FtsZ assembles into a polymeric ring at the center of the cell. Middle, using supported membranes and TIRF imaging, we could analyze the self-organization of FtsA and FtsZ into dynamic, cytoskeletal rings or treadmilling filaments (see inset). Right, with the help of this well-controlled in vitro system, we developed a mechanistic model of FtsZ-FtsA interaction on the cell membrane.

Team Catarina Alcarva (PhD student), Natalia Baranova (postdoc), Christine Mieck (postdoc), Michaela Steiner (laboratory technician)

Jan Maas

Stochastic Analysis

Current Projects

Gradient flow structures in chemical reaction networks | Curvature bounds for discrete interacting systems | Transport inequalities for quantum Markov processes

Selected Publications

Hairer M, Maas J, Weber H. 2014. Approximating rough stochastic PDEs. Comm. Pure Appl. Math. 67 (5), 776-870.

Carlen E, Maas J. 2014. An analog of the 2-Wasserstein metric in non-commutative probability under which the fermionic Fokker-Planck equation is gradient flow for the entropy. Comm. Math. Phys. 331 (3) 887-926.

Maas J. 2011. Gradient flows of the entropy for finite Markov chains. J. Funct. Anal. 261 (8), 2250-2292.

Exchange rate fluctuations, bacteria colony growth, and burning fronts are highly irregular systems subject to randomness or uncertainty. Mathematician Jan Maas develops new techniques for the mathematical study of such random phenomena in science and engineering.

Maas' recent work is inspired by methods from optimal transport, a subject originating in economics and engineering, that deals with the optimal allocation of resources. Recently, optimal transport has been used to establish deep and fascinating connections between seemingly unrelated problems in geometry, mathematical analysis, and probability.

Jan Maas aims to extend ideas from optimal transport theory to study stochastic processes. He now applies these techniques to diverse problems involving complex networks, chemical reaction systems, and quantum mechanics.

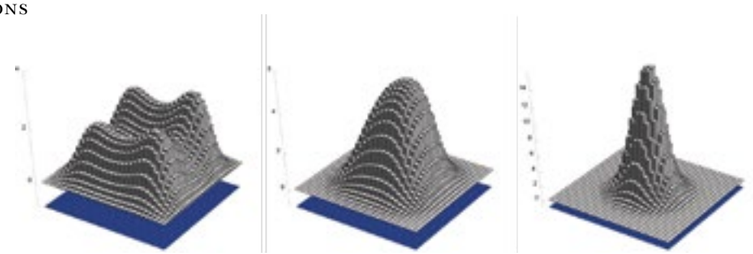
Another focus of the Maas group is on stochastic partial differential equations. These equations are commonly used to model high-dimensional random systems in science and engineering. Solutions to such equations are often so irregular that mathematicians cannot use existing methods to find them. Often, even finding an appropriate concept of a solution can be very challenging. The Maas group aims to develop robust mathematical techniques to study these equations, which will also lead to new insights into the underlying models.

Career

since 2014 Assistant Professor, IST Austria
2009–2014 Postdoc, University of Bonn, Germany
2009 Postdoc, University of Warwick, UK
2005–2009 PhD in Applied Mathematics, Delft University of Technology, The Netherlands

Selected Distinctions

2013–2014 Project leader in Collaborative Research Centre “The mathematics of emergent effects”
2009–2011 NWO Rubicon Fellowship



Gradient flow discretization of a fourth-order diffusion equation.

Team Dominik Forkert (scientific intern), Giovanni Zanco (postdoc)

Gaia Novarino

Genetic and Molecular Basis of Epilepsy and Cognitive Disorders

Epilepsy affects millions of people, many of them children. Often, epilepsy patients also suffer from autism or intellectual disability. Gaia Novarino asks whether all these disorders share common molecular mechanisms. She seeks to identify and study disease-causing mechanisms by analyzing both the genomes of patients and studying mouse models of the disease.

Epilepsy, autism, and intellectual disability often occur together in patients, comprising the neurodevelopmental disorder (NDD) spectrum. Gaia Novarino seeks to identify the genes responsible for these disorders by studying genetic forms of NDDs. Each gene identified probably only represents a fraction of all genes that cause this spectrum of disorders. Nevertheless, studying rare forms of epilepsy, autism, and intellectual disability can be extremely helpful as similarities among the functions of disease-causing genes may point to a small number of molecular mechanisms responsible for seizure syndromes. Information from rare inherited diseases could hence contribute to the development of treatments that also target more common forms of epilepsy. Since having joined IST Austria, publications by Gaia Novarino doubled the number of known causes of a neurodegenerative disorder associated with epilepsy, called hereditary spastic paraplegia, and identified mutations in the gene SETD5 as a relatively frequent cause of intellectual disability.

Selected Publications

Novarino G*, El-Fishawy P, Kayserili H, Meguid NA, Scott ES, Schroth J, Silhavy JL, Kara M, Khalil RO, Ben-Omran T, Ercan-Sencicek AG, Hashish AF, Sanders SJ, Gupta AR, Hashem HS, Matern D, Gabriel S, Sweetman L, Rahimi Y, Harris RA, State MW, Gleeson JG.* 2012. Mutations in the BCKD-kinase lead to a potentially treatable form of autism with epilepsy. Science. 338(6105): 394-397. (*Corresponding authors)

Novarino G, Fenstermaker AG, Zaki MS, Hofree M, Silhavy JL, Heiberg AD, Abdellateef M, Rosti B, Scott E, Mansour L, Masri A, Kayserili H, Al-Aama JY, Abdel-Salam GM, Karminejad A, Kara M, Kara B, Bozorgmehri B, Ben-Omran T, Mojahedi F, Mahmoud IG, Bouslam N, Bouhouche A, Benomar A, Hanein S, Raymond L, Forlani S, Mascaro M, Selim L, Shehata N, Al-Allawi N, Bindu PS, Azam M, Gunel M, Caglayan A, Bilguvar K, Tolun A, Issa MY, Schroth J, Spencer EG, Rosti RO, Akizu N, Vaux KK, Johansen A, Koh AA, Megahed H, Durr A, Brice A, Stevanin G, Gabriel SB, Ideker T, Gleeson JG*. 2014. Exome sequencing links corticospinal motor neuron disease to common neurodegenerative disorders. Science. (6170):506-511.

Kuechler A, Zink AM, Wieland T, Lüdecke HJ, Cremer K, Salviati L, Magini P, Najafi K, Zweier C, Czeschik JC, Aretz S, Endele A, Tamburrino F, Pinato C, Clementi M, Gundlach J, Maylahn C, Mazzanti L, Wohlleber E, Schwarzmayr T, Kariminejad R, Schlessinger A, Wieczorek D, Strom TM#, Novarino G #, Engels H#. 2014. Loss-of-function mutations of SETD5 cause intellectual disability and core phenotype of microdeletion 3p25.3 syndrome. EJHG. (# Contributed equally as senior authors)

Career

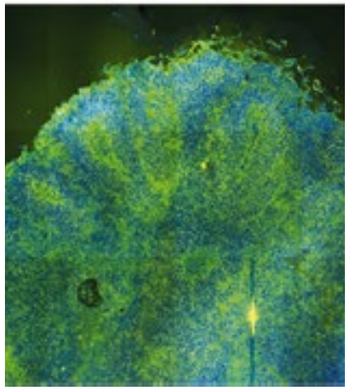
since 2014 Assistant Professor, IST Austria
2010–2013 Postdoc UCSD, La Jolla, USA (Joseph Gleeson Lab)
2006–2010 Postdoc ZMNH (Center for Molecular Neurobiology Hamburg), Germany andMDC/FMP Berlin, Germany (Thomas Jentsch Lab)
2006 PhD in Cell Biology, University "La Sapienza", Rome, Italy

Selected Distinctions

2014 Citizens United for Research in Epilepsy (CURE): Taking Flight Award
2012 Citizens United for Research in Epilepsy (CURE): Young Investigator Travel Award
2011 German Research Foundation (DFG): 2-year fellowship

Current Projects

Molecular mechanisms underlying autism spectrum disorders
The SETD5 gene in intellectual disability
Modeling Epileptic Encephalopathies in Human Brain Organoids



Embryonic stem cell-derived human cortical organoid stained for the radial glia marker Nestin (green) and nuclei (blue).

Team Alberto Coll Manzano (laboratory technician), Ximena Contreras Paniagua (PhD student), Elena Deliu (postdoc), Mike Liu (laboratory technician), Emanuela Morelli (postdoc), Eva Reinthaler (ISTFELLOW postdoc), Roberto Sacco (postdoc), Dora Tarlungeanu (PhD student), Mateja Tesulov (scientific intern)

Krzysztof Pietrzak

Cryptography

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 cryptography group at IST Austria works on theoretical and practical aspect 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 | Memory-Hard Functions | Cryptocurrencies

Selected Publications

Kiltz E, Pietrzak K, Szegedy M. 2013. Digital Signatures with Minimal Overhead from Indifferentiable Random Invertible Functions. CRYPTO. (1) 2013: 571-588.

Kiltz E, Pietrzak K, Cash D, Jain A, Venturi D. 2011. Efficient authentication from hard learning problems. EUROCRYPT. 7-26.

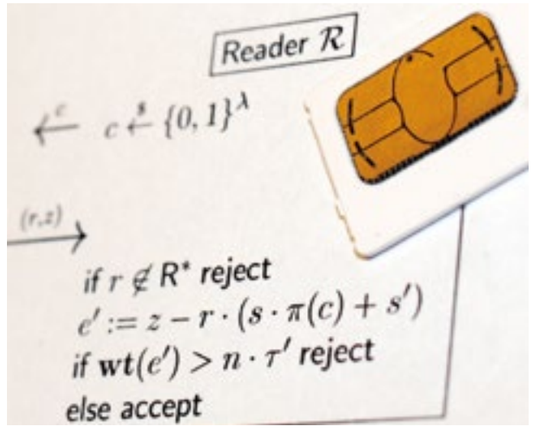
Dziembowski S, Pietrzak K. 2008. Leakage-resilient cryptography. IEEE Symposium on Foundations of Computer Science. 293-302.

Career

since 2011 Assistant Professor, IST Austria
2005–2011 Scientific staff member, Centrum Wiskunde & Informatica, Amsterdam, The Netherlands
2006 Postdoc, École Normale Supérieure, Paris, France
2005 PhD, ETH Zurich, Switzerland
2010 ERC Starting Grant

Selected Distinctions

2015 ERC Consolidator Grant
2010 ERC Starting Grant



Light-weight devices require simple and efficient cryptographic schemes.

Team Hamza Abusalah (PhD student), Joel Alwen (postdoc), Georg Fuchsbauer (postdoc), Peter Gazi (postdoc), Chethan Kamath Hosdurg (PhD student), Michal Rybar (PhD student)

Leonid Sazanov

Structural Biology of Membrane Protein Complexes

Current Projects

Mechanism of coupling between electron transfer and proton translocation in complex I | Structure of mammalian complex I | Structure and function of mitochondrial respiratory supercomplex | Structure and function of other membrane protein complexes relevant to bioenergetics

Selected Publications

Baradaran R, Berrisford JM, Minhas GS, Sazanov LA. 2013. Crystal structure of the entire respiratory complex I. Nature. 494, 443-8.

Efremov RG, Sazanov LA. 2011. Structure of the membrane domain of respiratory complex I. Nature. 476, 414-20.

Efremov RG, Baradaran R, Sazanov LA. 2010. The architecture of respiratory complex I. Nature. 465, 441-445.

Membrane proteins are responsible for many fundamental cellular processes including transport of ions and metabolites, energy conversion, and signal transduction. They are the target of about two thirds of modern drugs. There is an urgent need for the structural characterisation of many more membrane protein families.

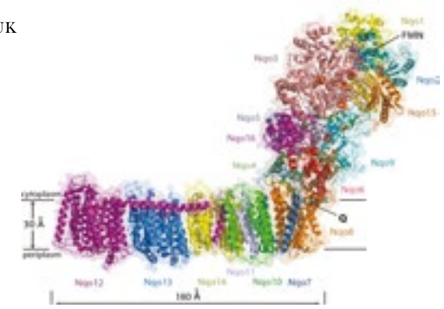
The Sazanov Group has a long-standing interest in the structural biology of membrane proteins. The main emphasis has been on complex I of the respiratory chain, a huge enzyme central to cellular energy production and involved in many common human pathologies. So far, they determined all the first (and still the only fully known) atomic structures of complex I. The structure of the entire complex suggests a uniquely elaborate mechanism of proton translocation, involving long-range conformational changes. The Sazanov group is verifying the mechanism via structural studies using both X-ray crystallography and single particle cryo-electron microscopy. For a complete mechanistic understanding, structural work is supplemented by site-directed mutagenesis and functional assays. They are also studying other related membrane protein complexes, such as hydrogenases and antiporters. Their studies will move the understanding of redox- and conformationally coupled proton pumps forward and help derive general and specific features of molecular design in these intricate biological machines. Medical implications are multifaceted, especially for complex I-related diseases.

Career

since 2015 Professor, IST Austria
2006 Program leader, MRC Mitochondrial Biology Unit, Cambridge, UK
2000 Group leader, MRC Mitochondrial Biology Unit, Cambridge, UK
1997 Research Associate, MRC Laboratory of Molecular Biology, Cambridge, UK
1994 Research Fellow, Dept. of Biochemistry, Imperial College, London, UK
1992 Postdoc, School of Biochemistry, University of Birmingham, UK
1990 Postdoc, Belozersky Institute of Physico-Chemical Biology, Moscow State University, Russia
1990 PhD in Biophysics, Moscow State University, Russia

Selected Distinctions

2013 Member of Faculty of 1000
2012 EMBO Grant
2009 AMGEN Grant
2004 Royal Society Grant
2002 Royal Society Grant
1992 Wellcome Trust fellowship



Structure of the entire respiratory complex I from *Thermus thermophilus*. Each subunit is coloured differently and labelled. Approximate location of the cell membrane is indicated.

Team Alexej Charnagalov (laboratory technician), Karol Fiedorczuk (scientific intern), Javier Gutierrez-Fernandez (postdoc), Karol Kaszuba (postdoc), James Letts (postdoc), Margherita Tambalo (scientific intern)

Robert Seiringer

Mathematical Physics

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 Publications

Seiringer R. 2014. Bose gases, Bose–Einstein condensation, and the Bogoliubov approximation. J. Math. Phys. 55, 075209.

Frank RL, Lewin M, Lieb EH, Seiringer R. 2013. A positive density analogue of the Lieb–Thirring inequality, Duke Math. J. 162, 435-495.

Grech P, Seiringer R. 2013. The Excitation Spectrum for Weakly Interacting Bosons in a Trap, Commun. Math. Phys. 322, 559-591.

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.

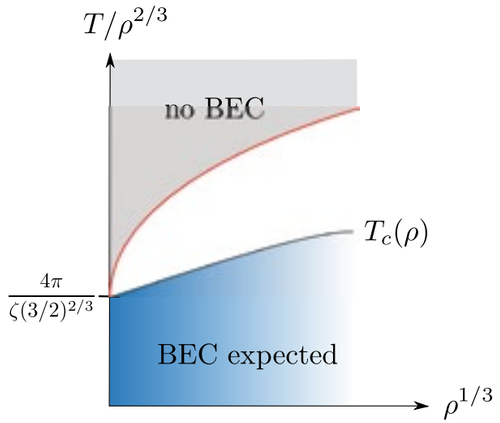
Ice and water may look different, but are in fact described by the same equations of quantum mechanics. How the same equations can lead to two such very different macroscopic manifestations is one of the questions that inspire the Seiringer group in their effort to precisely understand physical systems. 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, of which they seek to gain a thorough theoretical understanding.

Career

since 2013 Professor, IST Austria
2010–2013 Associate Professor, McGill University, Montreal, Canada
2005 Habilitation, University of Vienna, Austria
2003–2010 Assistant Professor, Princeton University, USA
2001–2003 Postdoc, Princeton University, USA
2000–2001 Assistant, University of Vienna, Austria
2000 PhD, University of Vienna, Austria

Selected Distinctions

2012–2017 William Dawson Scholarship
2012–2014 NSERC E.W.R. Steacie Memorial Fellowship
2009–2010 U.S. National Science Foundation CAREER Grant
2009 Henri Poincaré Prize of the International Association of Mathematical Physics
2004–2006 Alfred P. Sloan Fellow
2001–2003 Erwin Schrödinger Fellow



Phase diagram of a dilute Bose gas.

Team Simon Mayer (PhD student), Thomas Moser (PhD student), Marcin Napiórkowski (postdoc), Sören Petrat (ISTFELLOW postdoc), Phan Thanh Nam (ISTFELLOW postdoc)

Ryuichi Shigemoto

Molecular Neuroscience

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 Publications

Shinohara Y, Hirase H, Watanabe M, Itakura M, Takahashi M, Shigemoto R. 2008. Left-right asymmetry of the hippocampal synapses with differential subunit allocation of glutamate receptors. Proceedings of National Academy of Science. USA. 105:19498-19503.

Fukazawa Y, Shigemoto R. 2012. Intra-synapse-type and inter-synapse-type relationships between synaptic size and AMPAR expression. Current Opinion in Neurobiology. 22 (3), 446-452.

Wang W, Nakadate K, Masugi-Tokita M, Shutoh F, Aziz W, Tarusawa E, Lorincz A, Molnár E, Kesaf S, Li YQ, Fukazawa Y, Nagao S, Shigemoto R. 2014. Distinct cerebellar engrams in short-term and long-term motor learning. Proceedings of National Academy of Science. USA. 111:E188-193.

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.

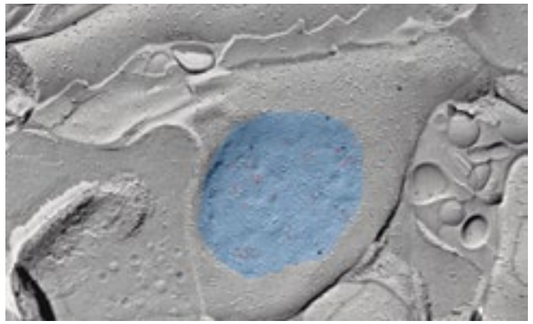
The release of neurotransmitters from a nerve cell into the synapse, where they act on receptors on the connecting nerve cell, is the primary way of information transmission and computation in the brain. The Shigemoto group studies the localization of single neurotransmitter receptors, ion channels and 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 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.

Career

since 2013 Professor, IST Austria
1998–2014 Professor, National Institute for Physiological Sciences, Okazaki, Japan
1990–1998 Assistant Professor, Kyoto University Faculty of Medicine, Kyoto, Japan
1994 PhD, Kyoto University, Japan
1985 MD, Kyoto University Faculty of Medicine, Japan

Selected Distinctions

ISI Highly Cited Researcher
2000 ISI Citation Laureate Award



Clustering of P/Q-type voltage dependent calcium channels (red) in the presynaptic active zone (blue) of parallel fiber-Purkinje cell synapses in the rat cerebellum.

Team Pradeep Bhandari (PhD student), Matthew Case (PhD student), Felipe Fredes Tolorza (postdoc), Harumi Harada (postdoc), David Kleindienst (PhD student), Elodie Le Monnier (laboratory technician), Yukihiro Nakamura (postdoc), Angelika Reichert (scientific intern), Manu Sharma (scientific intern), Maria Alejandra Silva Sifuentes (scientific intern), Klemens Weitenthaler (scientific intern), Huanghui Wu (scientific intern), Ming-Zhu Zhai (laboratory technician)

Sandra Siegert

Neuroimmunology in Health and Disease

Current Projects

A genetic atlas of microglial cells during development | Microglial dynamics in sequential removal and functional restoration of cell types | Molecular mechanism of healthy and diseased microglia in human retinal circuit formation

Selected Publications

Siegert S, Seo J, Kwon EJ, Rudenko A, Cho S, Wang W, Flood ZC, Martorell AJ, Ericsson M, Mungenast AE, Tsai L. 2015. The schizophrenia risk gene product miR-137 alters presynaptic plasticity. Nature Neuroscience. 18, 1008-1016.

Siegert S, Cabuy E, Scherf BG, Kohler H, Panda S, Le Y, Fehling HJ, Gaidatzis D, Stadler MBE, Roska BM. 2012. Transcriptional code and disease map for adult retinal cell types. Nature Neuroscience. 15(3), 487-495.

Siegert S, Scherf BG, Del Punta K, Didkovsky N, Heintz NM, Roska BM. 2009. Genetic address book for retinal cell types. Nature Neuroscience. 12(9), 1197-1204.

Microglia are commonly thought to be only involved in an active immune defense. However, recent studies have shown that microglia respond to their neuronal environment and influence synapse formation and maintenance. Moreover, genome-wide studies described several disease-associated genes, which have been related to microglial function. This raises the fascinating question of how microglia know when to alter neuronal circuit elements without inducing circuit malfunction.

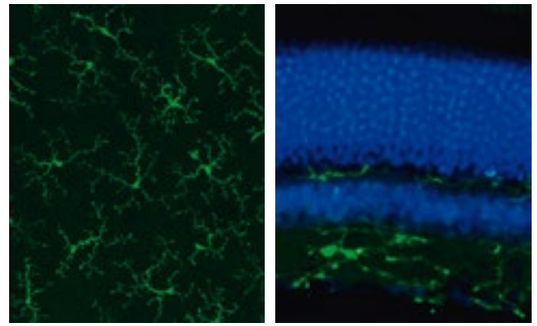
The main research focus of the Siegert Group is to understand how neurons and microglia interact with each other, and how malfunctions within this relationship impacts neuronal circuit formation and function in health and disease. They address this issue by taking advantage of the mammalian retina, which consists of morphologically well-defined cell types that are precisely mapped in their connection and functional properties. In the retina, microglial activation has been described in several inherited retinal degenerative diseases, however their role is unknown. In order to resolve these questions, they combine techniques from molecular biology, virology, genomics, (epi)genetics, computational, and multi-photon functional imaging. Additionally, they take advantage of reprogramming human induced pluripotent stem cells into three-dimensional retinal structures to study human disease-relevant aspects.

Career

since 2015 Assistant Professor, IST Austria
2011–2015 Postdoctoral Associate, MIT, Cambridge/MA, USA
2005–2010 PhD Student, Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland

Selected Distinctions

2014 Young Investigator travel award
2013 SWISS OphthAWARD
2012 Human Frontier Science Program (HFSP) long-term fellowship
2011 Molecular Biology Organization (EMBO) long-term fellowship
2011 Swiss National Science Foundation (SNSF), fellowship for prospective researchers



On the left: Top view of microglial cells (green) in the mouse retina.
On the right: Side view of the retina with the three nuclei layers labeled in blue.

Team Katarina Bartalska (laboratory technician), Gloria Colombo (scientific intern), Alessandro Venturino (laboratory technician)

Daria Siekhaus

Invasive Migration

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 how "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 and metastasis.

Current Projects

Communication between hemocytes and the barriers they move through | Regulation of adhesion during migration | Identifying the role of a novel transporter during invasive migration

Selected Publications

Ratheesh A, Belyaeva V, Siekhaus DE. 2015. Drosophila immune cell migration and adhesion during embryonic development and larval immune responses. Current Opinion in Cell Biology. 36, 71-79.

Siekhaus D, Haesemeyer M, Moffitt O, Lehmann R. 2010. RhoL controls invasion and Rap1 localization during immune cell transmigration in Drosophila. Nature Cell Biology. 12(6), 605-610.

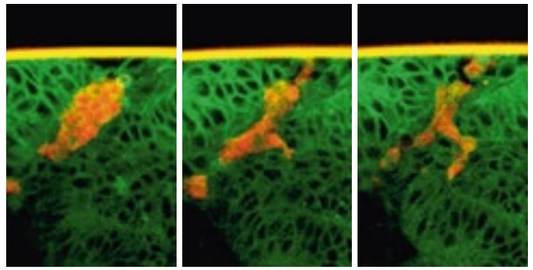
Siekhaus D, Drubin DG. 2003. Spontaneous receptor-independent heterotrimeric G protein signaling in an RGS mutant. Nature Cell Biology. 5(3), 231-235.

Career

since 2012 Assistant Professor, IST Austria
2003–2011 Research Scientist, Department of Developmental Genetics, Skirball Institute, New York University Medical Center, USA
1999–2003 Postdoctoral Fellow, University of California, Berkeley, USA
1998 PhD, Stanford University, USA

Selected Distinctions

2012 Marie Curie Career Integration Grant
2003–2005 NIH Fellowship
2000–2003 NSRA Fellowship



Immune cells (red) of the fruit fly Drosophila melanogaster.

Team Vera Belyaeva (PhD student), Julia Biebl (laboratory technician), Matthew Doerfler (scientific intern), Shamsi Emtenani (PhD student), Attila György (laboratory technician), Aparna Ratheesh (postdoc), Kateryna Shkarina (scientific intern), Adam Szabo (scientific intern), Katarina Valosková (PhD student), Jana Veselá (laboratory technician)

Michael Sixt

Morphodynamics of Immune Cells

Immune cells zip through our body at high speed to fight off infections and diseases. The Sixt group works at the interface of cell biology and immunology to investigate how cells are able to migrate through tissues.

Most cells in our bodies are stationary, forming solid tissues and encapsulated organs. One exception are leukocytes, immune cells essential for both the innate and adaptive immune response to infections. Leukocytes migrate with extraordinary speed, and are used by the Sixt group as a model to study cell migration. The group works at the interface of cell biology, immunology, and biophysics and aims to identify mechanistic principles that then might be generalized to other migrating cells, such as metastasizing cancer cells or migratory cells during development or regeneration. A current focus of research is how the cell's internal skeleton, the actin cytoskeleton, generates the force to deform the cell body and how this force is transduced to the surrounding tissue in order to move the cell forward. The group also investigates other, closely related aspects, such as cell polarization and guidance within tissues. To challenge their findings in the context of living tissues, the Sixt group has developed tissue explants and whole-animal imaging techniques that complement studies in reductionist *in vitro* systems.

Current Projects

Environmental control of leukocyte migration | Cellular force generation & transduction | Invasion of tissue barriers

Selected Publications

Weber M, Hauschild R, Schwarz J, Moussion C, de Vries I, Legler DF, Luther SA, Bollenbach T, Sixt M. 2013. Interstitial dendritic cell guidance by haptotactic chemokine gradients. Science. 339(6117):328-332.

Kiermaier E, Moussion C, Veldkamp CT, Gerardy-Schahn R, de Vries I, Williams LG, Chaffee GR, Phillips AJ, Freiberger F, Imre R, Taleski D, Payne RJ, Braun A, Förster R, Mechtler K, Mühlenhoff M, Volkman BF, Sixt M. 2016. Polysialylation controls dendritic cell trafficking by regulating chemokine recognition. Science. 351(6269), 186-90.

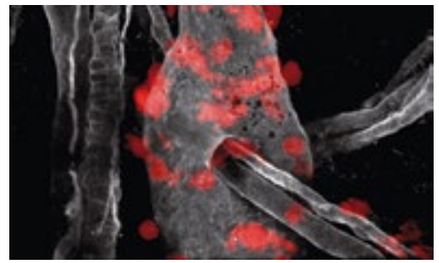
Lämmermann T, Bader BL, Monkley SJ, Worbs T, Wedlich-Söldner R, Hirsch K, Keller M, Förster R, Critchley DR, Fässler R, Sixt M. 2008. Rapid leukocyte migration by integrin-independent flowing and squeezing. Nature. 453(7191), 51-55.

Career

since 2013 Professor, IST Austria
2010–2013 Assistant Professor, IST Austria
2008–2010 Endowed Professor, Peter Hans Hofschneider Foundation for Experimental Biomedicine
2005–2010 Group Leader, Max Planck Institute of Biochemistry, Martinsried, Germany
2003–2005 Postdoc, Institute for Experimental Pathology, Lund, Sweden
2003 MD, University of Erlangen, Germany
2002 Full approbation in human medicine

Selected Distinctions

2014 EMBO Member
2013 European Biophysical Societies Association (EBSA) Young Investigator Medal
2013 Elected member of the "Young Academy" of the Austrian Academy of Sciences
2012 Ignaz L. Lieben Award
2011 ERC Starting Grant
2011 FWF START Award
2008 Endowed Professor of the Peter Hans Hofschneider Foundation
2003 Novartis research price for the best medical dissertation at the University of Erlangen, Germany



Cells entering a lymph vessel.

Team Frank Assen (scientific intern), Markus Brown (scientific intern), Ingrid de Vries (senior laboratory technician), Miroslav Hons (postdoc), Eva Kiermaier (postdoc), Aglaja Kopf (PhD student), Alexander Leithner (PhD student), Christoph Mayr (scientific intern), Matthias Mehling (postdoc), Christine Moussion (postdoc), Jan Müller (scientific intern), Maria Nemethova (senior laboratory technician), Jörg Renkawitz (ISTFELLOW postdoc), Anne Reversat (postdoc), Jan Schwarz (PhD student), Kari Vaahtomeri (postdoc)

Gašper Tkačik

Theoretical Biophysics and Neuroscience

Current Projects

Visual encoding in the retina | Genetic regulation during early embryogenesis | Collective dynamics in groups of organisms

Selected Publications

Cepeda-Humerez SA, Rieckh G, Tkačik G. 2015. Stochastic proofreading mechanism alleviates crosstalk in transcriptional regulation. Phys Rev Lett. 115: 248101.

Tkačik G, Mora T, Marre O, Amodei D, Palmer SE, Berry MJ 2nd, Bialek W. 2015. Thermodynamics for a network of neurons: Signatures of criticality. Proc Nat'l Acad Sci USA. 112: 11508-11513.

Hermundstad AM, Briguglio JJ, Conte MM, Victor JD, Balasubramanian V, Tkačik G. 2014. Variance predicts salience in central sensory processing. eLife. 10.7554.

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.

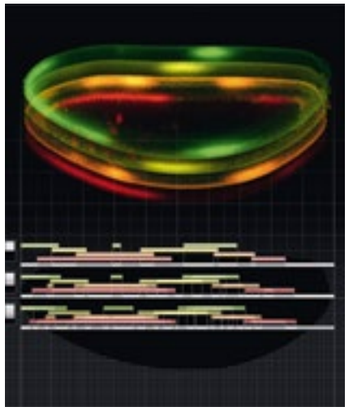
The Tkačik group focuses on information flow in biological networks, using tools from statistical physics of disordered systems and information theory to analyze, compare and model examples of biological computation. This biological computation takes place across a large range of time scales and is implemented 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 and neural coding to the collective motion of groups of organisms. For example, the Tkačik group studies how the visual systems of various organisms have adapted to their environments to efficiently extract information from natural stimuli and send it to the central nervous system.

Career

since 2011 Assistant Professor, IST Austria
2008–2010 Postdoc, University of Pennsylvania, Philadelphia, USA
2007 Postdoc, Princeton University, USA
2007 PhD, Princeton University, USA

Selected Distinctions

2012 HFSP Grant
2006 Charlotte E Procter Honorific Fellowship, Princeton University
2003 Burroughs-Wellcome Fellowship, Princeton University
2002 Golden sign of the University of Ljubljana



Analyzing positional information during fruit fly development.

Team Anna Andersson (joint postdoc with Guet group), Katarina Bodova (postdoc), Vicente Botella-Soler (postdoc), Sarah Cepeda Humerez (PhD student), Matthew Chalk (postdoc), Daniele De Martino (ISTFELLOW postdoc), Jan Humplik (PhD student), Anna Levina (joint ISTFELLOW postdoc with Csicsvari group), Gabriel Mitchell (postdoc), Roshan Prizak (joint PhD student with Barton group), Georg Rieckh (PhD student), Cristina Savin (ISTFELLOW postdoc), Thomas Sokolowski (postdoc)

Caroline Uhler

Algebraic Statistics and Mathematical Biology

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 Publications

Uhler C, Raskutti G, Bühlmann P, Yu B. 2013. Geometry of faithfulness assumption in causal inference. Annals of Statistics. 41(2), 436-463.

Uhler C, Wright SJ. 2013. Packing ellipsoids with overlap. SIAM Review. 55(4), 671-706.

Uhler C. 2012. Geometry of maximum likelihood estimation in Gaussian graphical models. Annals of Statistics. 40(1), 238-261.

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.

Career

since 2011 Assistant Professor, IST Austria
2013 Research Fellow, Theoretical Foundations of Big Data Analysis, Simons Institute, University of California, Berkeley, USA
2012 Postdoc, Seminar of Statistics, ETH Zurich, Switzerland
2011 Postdoc, Institute of Mathematics and its Applications, University of Minnesota, Minneapolis, USA
2011 PhD, University of California, Berkeley, USA

Selected Distinctions

2014 Elected Member of the International Statistical Institute (ISI)
2010–2011 Janggen-Poehn Fellowship
2007–2010 International Fulbright Science and Technology Award
2006 Best Student Award of the University of Zurich

Gaussian distributions on three nodes for which causal inferenace fails.

Team Anna Klimova (postdoc), Abraham Martin del Campo Sanchez (postdoc), Lenka Matejovicova (PhD student), Fatemeh Mohammadi (ISTFELLOW postdoc), Patrik Noren (ISTFELLOW postdoc), Elisa Perrone (scientific intern), Liam Solus (postdoc)

Beatriz Vicoso

Sex-Chromosome Biology and Evolution

Current Projects

Sex chromosome turnover | Dosage compensation in female-heterogametic species | Ancient homomorphic sex chromosomes

Selected Publications

Pal A, Vicoso B. 2015. The X chromosome of hemipteran insects: conservation, dosage compensation and sex-biased expression, Genome Biology and Evolution. doi: 10.1093/gbe/evv215.

Vicoso B, Bachtrog D. 2015. Numerous transitions of sex chromosomes in Diptera, PLoS Biology. 13(4): e1002078.

Vicoso B, Bachtrog D. 2013. Reversal of an ancient sex chromosome to an autosome in Drosophila. Nature. 499(7458), 332-335.

Sex chromosomes, such as the X and Y of mammals, are involved in sex-determination in many animal and plant species. Their sex-specificity leads them to evolve differently from other chromosomes, and acquire distinctive biological properties. The Vicoso group investigates how sex chromosomes evolve over time, and what biological forces are driving their patterns of differentiation.

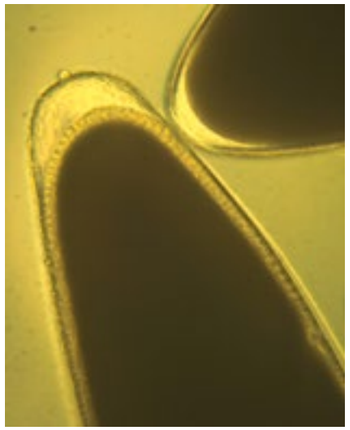
The Vicoso Group is interested in understanding several aspects of the biology of sex chromosomes, and the evolutionary processes that shape their peculiar features. By combining the use of next-generation sequencing technologies with studies in several model and non-model organisms, they can address a variety of standing questions, such as: why do some Y chromosomes degenerate while other remain homomorphic, and how does this relate to the extent of sexual dimorphism of the species? What forces drive some species to acquire global dosage compensation of the X, while others only compensate specific genes? What are the frequency and molecular dynamics of sex-chromosome turnover?

Career

since 2015 Assistant Professor, IST Austria
2009–2014 Postdoctoral researcher, UC Berkeley
2010 PhD, University of Edinburgh

Selected Distinctions

2016–2019 FWF Standalone grant
2011 DeLill Nasser travel award from the Genetics Society of America
2003–2007 PhD Scholarship from the Portuguese Science and Technology Foundation, administered through the GABBA Graduate Program in of Areas of Basic and Applied Biology



Sex is determined early in embryogenesis

Team Adrien Bessy (scientific intern), Claudia Engelmaier-Weber (laboratory technician), Christelle Fraisse (joint postdoc with Barton group), Ann Huylmans (postdoc), Réka Kelemen (scientific intern), Ariana Macon (laboratory technician), Marion Picard (postdoc)

Uli Wagner

Combinatorics, Geometry and Topology

Current Projects

Higher-dimensional embeddings (generalizations of graph planarity) | Discrete isoperimetric inequalities and higher-dimensional expanders | Topological Tverberg-type problems and multiple self-intersections of maps

Selected Publications

Mabillard I, Wagner U. 2014. Eliminating Tverberg Points, I. An analogue of the Whitney trick. Proc. 30th Ann. Symp. on Comput. Geom. (SoCG). 171-180.

Matoušek J, Sedgwick E, Tancer M, Wagner U. 2014. Embeddability in the 3-sphere is decidable. Proc. 30th Ann. Symp. on Comput. Geom. (SoCG). 78-84.

Matoušek M, Tancer M, Wagner U. 2011. Hardness of embedding simplicial complexes in Rd . J. Eur. Math. Soc. 13(2), 2011, 259-295.

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. Their research combines geometry and topology with combinatorics, as they study questions in geometry and topology from a combinatorial viewpoint, while also applying methods from topology to problems in combinatorics, discrete geometry and theoretical computer science. The group also asks to what extent classical questions in topology and geometry can be answered in a mechanical way, i.e. by a computer program.

Career

since 2013 Assistant Professor, IST Austria
2012–2013 SNSF Research Assistant Professor, Institut de Mathématiques de Géométrie et Applications, EPFL Lausanne, Switzerland
2008–2012 Senior Research Associate, Institute of Theoretical Computer Science, ETH Zurich, Switzerland
2006–2008 Postdoctoral Researcher, Institute of Theoretical Computer Science, ETH Zurich, Switzerland
2004–2006 Postdoc, Einstein Institute for Mathematics, The Hebrew University of Jerusalem, Israel
2004–2004 Postdoc, Department for Applied Mathematics, Univerzita Karlova, Prague, Czech Republic
2003–2003 Postdoc, Mathematical Sciences Research Institute, Berkeley, USA
2000–2004 PhD in Mathematics, ETH Zurich, Switzerland

Selected Distinctions

2012 Research Assistant Professorship Grant of Swiss National Science Foundation (SNSF)
2012 Co-winner of Best Paper Award at Symposium of Discrete Algorithms (SODA)
2004 Richard Rado Prize

Team Sergey Avvakumov (student intern), Arnaud de Mesmay (ISTFELLOW postdoc), Marek Filakovský (student intern), Peter Franek (postdoc), Radoslav Fulek (ISTFELLOW postdoc), Kristóf Huszár (PhD student), Marek Krčál (joint ISTFELLOW postdoc with Edelsbrunner group), Isaac Mabillard (PhD student), Zuzana Masárová (joint PhD student with Edelsbrunner group), Stephan Zhechev (PhD student)

Chris Wojtan

Computer Graphics and Physics Simulation

Deceptively realistic physical motions are essential for virtual reality, animated movies, and computer games. Complex calculations and models operate in the background to create these accurate simulations. The Wojtan group uses numerical and geometric techniques to provide the basis for complex animations and graphics.

The realistic simulation of complex processes in the physical world is the focus of research in the Wojtan group. Using numerical and geometric techniques, they create computer simulations of physical phenomena such as fluids and deformable bodies. 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 solution of complex equations with semi-analytical integration, in order to efficiently simulate highly detailed phenomena such splashing water, soap foams, and fracturing stone.

Career

since 2015 Professor, IST Austria
2011-2015 Assistant Professor, IST Austria
2010 PhD, Georgia Institute of Technology, Atlanta, USA

Selected Distinctions

2015 Eurographics Young Researcher Award
2015 Gunter Enderle Best Paper Award at Eurographics 2015
2014 ERC Starting Grant
2013 Microsoft Visual Computing Award
2011 Georgia Institute of Technology Sigma Chi Best PhD Thesis Award
2010 Outstanding Graduate Research Assistant Award (Georgia Institute of Technology)
2005 National Science Foundation Graduate Research Fellowship
2004 Presidential Fellowship
2003 James Scholarship

Current Projects

Efficient simulation of fluid and fracture dynamics | Numerical and geometric algorithms for solving partial differential equations | Algorithms for re-using simulation data

Selected Publications

Hahn D, Wojtan C. 2015. High-resolution brittle fracture simulation with boundary elements. ACM Transactions on Graphics 34(4) (Proceedings of SIGGRAPH 2015). Article 151.

Ando R, Thuerey N, Wojtan C. 2013. Highly adaptive liquid simulations on tetrahedral meshes. ACM Transactions on Graphics 32(4) (Proceedings of SIGGRAPH 2013). Article 10.

Wojtan C, Thürey N, Gross M, Turk G. 2009. Deforming meshes that split and merge. ACM Transactions on Graphics 34(4) (Proceedings of SIGGRAPH 2009). Article 76.

Simulation of highly detailed surface tension phenomena such as the formation of water droplets using mesh-based surface tracking.

Team Ryoichi Ando (postdoc), Morten Bojsen-Hansen (PhD student), Ewa Gajda-Zagórska (postdoc), David Hahn (PhD student), Stefan Jeschke (postdoc), Selver Pepic (scientific intern)

New Professors

Georgios Katsaros

is a condensed matter physicist interested in self-assembled semiconductor nanostructures and their electronic transport properties at low temperatures. After his undergraduate studies in Physics at the University of Patras (Greece), Katsaros joined the group of Klaus Kern at the MPI for Solid State Research in Stuttgart for his PhD in 2002, working in the field of surface science. He then moved to the group of Silvano De Franceschi at CEA Grenoble before working as a group leader focusing on the development of new Ge self-assembled nanostructures at the Institute for Integrative Nanosciences, a part of the Leibniz Institute for Solid State and Materials Research in Dresden. Since 2012, Katsaros has been working as group leader at the Johann-Kepler-University in Linz. He will move to IST Austria as Assistant Professor in early 2016.

Tamás Hausel

is a mathematician interested in combinatorial, differential, and algebraic geometry and topology. After his studies at Eötvös Lórand University in Budapest, Hausel obtained a certificate of Advanced Mathematics with Distinction at the University of Cambridge, where he also received his PhD in Pure Mathematics in 1998. He then became a member of the Institute for Advanced Study in Princeton and a Miller Research Fellow of the Miller Institute for Basic Research in Science at the University of California, Berkeley. From 2002–2010, Hausel was Assistant and Associate Professor at the Department of Mathematics at the University of Texas in Austin. In addition, he joined the Mathematical Institute at the University of Oxford as University Lecturer in Pure Mathematics (2007–2012), became a Tutorial Fellow at Wadham College, Oxford (2007–2012) and also was a Royal Society University Research Fellow at the Mathematical Institute of the University of Oxford (2005–2012). Since 2012, Hausel has been Full Professor and director of the Chair of Geometry at EPFL in Lausanne. Hausel focuses on the geometry, topology and arithmetic of several moduli spaces. He applies these studies to number theory as well as to theoretical physics. In 2013, Hausel received an ERC Advanced Grant for his work on “Arithmetic and physics of Higgs moduli spaces”. Hausel will join IST Austria in fall 2016.

Johannes Fink

is a physicist whose main field of research is the interaction of matter and light which he studies using superconducting circuit quantum electrodynamics (QED) and integrated opto- and electro-mechanical devices. After his undergraduate studies at the University of Vienna from 2002 to 2007 he joined the lab of Professor Andreas Wallraff at ETH Zurich for his master’s thesis and his graduate studies. He managed to observe the geometric phase in an electrical circuit for the first time and continued to work on circuit QED experiments. In his doctoral work, he studied a number of important aspects of the resonant interaction between microwave photons and superconducting qubits. Since 2012, Fink has been a postdoc and senior staff scientist with Professor Oskar Painter at the Institute for Quantum Information and Matter at the California Institute of Technology, where he studied dielectric mechanical oscillators in their motional quantum ground state. Fink joins IST Austria as Assistant Professor in January 2016.

Grants Active or Acquired in 2015

BARTON GROUP

Limits to selection in biology and in evolutionary computation, FP7 ERC Advanced Grant, €1'976'000, 7/2010-6/2015

Speed of Adaptation in Population Genetics and Evolutionary Computation, FP7 Cooperation ICT-2013 9.3, €584'000, 1/2014-12/2016

Mating system and the evolutionary dynamics of hybrid zones, FP7 People MC-IIF, €179'000, 5/2014-6/2017

BENKOVÁ GROUP

Hormone cross-talk drives nutrient dependent plant development, FWF Int. Coop. (ANR), €349'000, 1/2015-12/2017

FONDECYT, €32'000, 12/2014-12/2015

BICKEL GROUP

Distributed 3D Object Design, H2020-MSCA ITN, €256'000, 1/2015-12/2018

Soft-bodied intelligence for Manipulation, H2020-ICT, 261'000, 5/2015-4/2019

BOLLBACK GROUP

Selective Barriers to Horizontal Gene Transfer, H2020 ERC Consolidator Grant, €1'821'000, 6/2015-5/2020

Relevance of phage transduction in transfer and persistence of antibiotic resistance in the medical environment, NFB, €120'000, 3/2016-2/2019

BOLLENBACH GROUP

Optimality principles in responses to antibiotics, FP7 People MC-CIG, €100'000, 2/2013-1/2017

Revealing the mechanisms underlying drug interactions, FWF-stand alone, €353'000, 1/2015-12/2017

Revealing the fundamental limits of cell growth, HFSP Program Grant, €256'000, 9/2013-8/2016

OEAW-APART fellowship, €225'000, 5/2012-4/2015

CHATTERJEE GROUP

RISE Rigorous Systems Engineering, FWF-NFN, €464'000, 3/2011-2/2015

Modern Graph Algorithmic Techniques in Formal Verification, FWF-stand alone, €107'000, 9/2011-8/2015

Quantitative Graph Games: Theory and Applications, FP7 ERC Starting Grant, €1'163'000, 12/2011-11/2016

SHINE Systematic Methods in Systems Engineering, FWF-NFN, €372'000, 3/2015-2/2019

Microsoft Research Faculty Fellowship, €143'000, 4/2011-3/2016

CREMER GROUP

Host-Parasite Coevolution, DFG, €128'000, 11/2010-12/2016

Social Vaccination in Ant Colonies: from Individual Mechanisms to Society Effects, FP7 ERC Starting Grant, 1'278'000, 11/2010-3/2015

Individual function and social role of oxytocin-like neuropeptides in ants, WWTF, €163'000, 1/2014-12/2017

CSICSVARI GROUP

Memory-related information processing in neuronal circuits of the hippocampus and entorhinal cortex, FP7 ERC Starting Grant, €1'441'000, 11/2011-10/2016

IN-SENS inter-and intracellular signalling in schizophrenia, FP7 People MC-ITN, €234'000, 10/2013-9/2017

Interneuron plasticity during spatial learning, FWF DFG-FOR, €256'000, 1/2015-12/2017

ERASMUS plus, €2'000, 6/2015-9/2015

EDELSBRUNNER GROUP

Topological Complex Systems, FP7 Cooperation-ICT, €498'000, 10/2012-9/2015

Persistent Homology - Images, Data and Maps, FP7 People MC-IEF, €248'000, 4/2014-3/2016

ERDŐS GROUP

Random matrices, universality and disordered quantum systems, FP7 ERC Advanced Grant, €1'755'000, 3/2014-2/2019

FRIML GROUP

Polarity and subcellular dynamics in plants, FP7 ERC Starting Grant, €1'269'000, 4/2013-1/2017

Effects of strigolactone analogues on subcellular distribution of dynamic PIN proteins in Arabidopsis, OeAD-WTZ, €3'000, 1/2015-12/2016

Chinese Scholarship Council, €14'000, 10/2014-9/2015

Chinese Scholarship Council, €58'000, 10/2015-9/2019

OeAD-Aktion Österreich-Slowakei, €9'000, 2/2015-7/2015

EMBO LTF Long term fellowship, €76'000, 2/2016-2/2018

Körber Prize, €41'000, 04/2015-03/2017

OeAD Scholarship Foundation of the Republic of Austria, €4'000, 01/2016-4/2016

GUET GROUP

Multi-Level Conflicts in Evolutionary Dynamics of Restriction-Modification Systems, HFSP Young Investigators' Grant, €263'000, 11/2011-10/2015

The Systems Biology of Transcriptional Read-Through in Bacteria: from Synthetic Networks to Genomic Studies, FP7 MC-IEF, €187'000, 3/2014-2/2017

Effects of Stochasticity on the Function of Restriction-Modification Systems at the Single-Cell Level, OEAW DOC fellowship, €107'000, 1/2015-12/2017

SNF Fellowship, €55'000, 10/2013-3/2015

SNF Fellowship, €66'000, 10/2015-3/2017

Design principles underlying genetic switch architecture, OeAW DOC fellowship, €113'000, 1/2016-12/2018

HEISENBERG GROUP

Modulation of adhesion function in cell-cell contact formation by cortical tension, EMBO LTF, €75'000, 7/2013-6/2015

Cell- and Tissue Mechanics in Zebrafish Germ Layer Formation, FWF-Hertha Firnberg, €214'000, 2/2012-1/2015

Control of Epithelial Cell Layer Spreading in Zebrafish, FWF-DACH DFG, €345'000, 5/2012-4/2015

Nano-Analytics of Cellular Systems, FWF-DK, €162'000, 3/2014-2/2018

Cell Cortex and Germ Layer Formation in Zebrafish Gastrulation, FWF-DACH DFG, €304'000, 10/2014-9/2017

WTZ Scientific exchange with India, €6'000, 1/2015-12/2016

HENZINGER GROUP

RISE Rigorous Systems Engineering, FWF-NFN, €465'000, 3/2011-2/2015

QUAREM Quantitative Reactive Modeling, FP7 ERC Advanced Grant, €2'326'000, 5/2011-4/2016

The Wittgenstein Prize, FWF, €1'500'000, 1/2014-12/2018

SHINE Systematic Methods in Systems Engineering, FWF-NFN, €490'000, 3/2015-2/2019

Automated Tutoring System for Automata Theory, Microsoft Research Education Studio Award, €7'000, 1/2011-12/2016

HIPPENMEYER GROUP

Molecular Mechanisms of Cerebral Cortex Development, FP7 People MC-CIG, €100'000, 9/2013-8/2017

Quantitative Structure-Function Analysis of Cerebral Cortex Assembly at Clonal Level, HFSP RGP, €270'000, 9/2014-8/2017

Mapping Cell-Type Specificity of the Genomic Imprintome in the Brain, NFB Life Science call 2013, €245'000, 3/2015-2/2018

HOF GROUP

Experimental studies of the turbulence transition and transport processes in turbulent Taylor-Couette currents, DFG-FOR, €273'000, 12/2013-11/2016

Decoding the complexity of turbulence at its origin, FP7 ERC Starting Grant, €1'397'000, 6/2013-12/2017

Alexander von Humboldt-Foundation, €25'000, 4/2015-11/2015

JANOVJAK GROUP

Optical NT sensor, FFG-FEMtech, €8'000, 9/2014-2/2015

Optical drug targets, FFG-FEMtech, €8'000, 8/2014-1/2015

MIC-SN Microbial Ion Channels for Synthetic Neurobiology, FP7 People MC-CIG, €100'000, 3/2012-2/2016

MolTag Molecular Drug Targets, FWF-DK, €196'000, 3/2015-2/2019

In situ real-time imaging of neurotransmitter signaling using designer optical sensors, HFSP Young Investigators' Grant, €267'000, 8/2012-1/2016

Ramon Areces Foundation, €26'000, 10/2014-9/2015

Ramon Areces Foundation, €26'000, 10/2015-9/2016

JONAS GROUP

Mechanisms of transmitter release at GABAergic synapses, FWF-stand alone, €494'000, 10/2012-9/2017

Nanophysiology of fast-spiking, parvalbumin-expressing GABAergic interneurons, FP7 ERC Advanced Grant, €2'500'000, 6/2011-2/2017

Presynaptic calcium channels distribution and impact on coupling at the hippocampal mossy fiber synapse, EMBO LTF, €76'000, 3/2016-3/2018

KATSAROS GROUP

Towards Spin qubits and Majorana fermions in Germanium selfassembled hut-wires, FP7 ERC Starting Grant, 1'323'000, 2/2016-12-2018

KICHEVA GROUP

Coordination of Patterning And Growth in the Spinal Cord, H2020 ERC Starting Grant, €1'499'000, 7/2016-6/2021

KOLMOGOROV GROUP

Discrete Optimization in Computer Vision: Theory and Practice, FP7 ERC Consolidator Grant, €1'642'000, 6/2014-5/2019

LAMPERT GROUP

Lifelong Learning of Visual Scene Understanding, FP7 ERC Starting Grant, €1'465'000, 1/2013-12/2017

LOOSE GROUP

Self-Organization of the Bacterial Cell, H2020 ERC Starting Grant, €1'497'000, 4/2016-3/2021

The biochemical basis of PAR polarization, FWF-Hertha Firnberg, €227'000, 1/201612-2018

Reconstitution of bacterial cell wall synthesis, EMBO LTF, €87'000, 1/2016-12/2017

NOVARINO GROUP

Modeling Epileptic Encephalopathies in Human Brain Organoids, CureEpilepsy, €80'000, 1/2015-12/2015

Transmembrane Transporters in Health and Disease, FWF-SFB, €348'000, 2/2015-1/2018

Molecular Drug Targets, FWF-DK, €196'000, 3/2015-2/2019

PIETRZAK GROUP

Provable Security for Physical Cryptography, FP7 ERC Starting Grant, €1'005'000, 9/2011-10/2015

Teaching Old Crypto New Tricks, H2020 ERC Consolidator Grant, €1'882'000, 4/2016-3/2021

SAZANOV GROUP

The crystalization and co-crystal structure determination of bacterial mitochondrial complex I, Bayer AG, €150'000, 5/2015-10/2016

Atomic-Resolution Structures of Mitochondrial Respiratory Chain Supercomplexes, FEBS fellowship, €77'000, 1/2016-12/2018

SEIRINGER GROUP

Structure of the Excitation Spectrum for Many-Body Quantum Systems, FWF-stand alone, €315'000, 4/2015-3/2018

SHIGEMOTO GROUP

Anatomical and Functional Properties of Auditory Nerve Synapses, NIH, €14'000, 3/2014-2/2015

Anatomical and Functional Properties of Auditory Nerve Synapses, NIH, €17'000, 3/2015-2/2016

Localization of ion channels and receptors by two and three-dimensional immunoelectron microscopic approaches, FP7 HBP, €234'000, 4/2014-3/2016

High resolution tagging for ion channels in neural membrane, FWF Int.Coop. (JSPS), €278'000, 7/2014-6/2016

Mechanism of formation and maintenance of input side-dependent asymmetry in the hippocampus, OeAW DOC fellowship, €113'000, 1/2016-12/2018

SIEKHAUS GROUP

Breaking barriers: Investigating the junctional and mechanobiological changes underlying the ability of Drosophila immune cells to invade an epithelium, FP7 People MC-IIF, €179'000, 3/2013-2/2015

Investigating the role of transporters in invasive migration through junctions, FP7 People MC-CIG, €100'000, 4/2013-3/2017

Examination of the role of a MFS transporter in the migration of Drosophila immune cells, OeAW DOC fellowship, €71'000, 7/2015-6/2017

OeAD-Aktion Österreich-Slowakei, €2'000, 1/2015-4/2015

SIXT GROUP

Stromal Cell-immune Cell Interactions in Health and Disease, FP7 People MC-ITN, €217'000, 1/2012-12/2015

Cell migration in complex environments: from in vivo experiments to theoretical models, HFSP-Program Grant, €254'000, 11/2011-4/2015

Role of the WAVE-complex in the haematopoietic System, DFG-SBH, €190'000, 11/2013-10/2016

Molecular and system level view of immune cell migration, EMBO LTF, €97'000, 3/2015-2/2017

Cytoskeletal force generation and force transduction of migrating leukocytes, FP7 ERC Starting Grant, €1'458'000, 4/2012-3/2017

Cytoskeletal force generation and force transduction of migrating leukocytes, FWF START, €200'000, 8/2011-7/2017

Nano-Analytics of Cellular Systems, FWF-DK, €162'000, 3/2014-2/2018

Modeling of Polarization and Motility of Leukocytes in Three-Dimensional Environments, WWTF, €160'000, 3/2014-2/2018

TKAČIK GROUP

Sensitivity to higher-order statistics in natural scenes, FWF-stand alone, €352'000, 9/2013-8/2017

Information processing and computation in fish groups, HFSP Program Grant, €269'000, 10/2012-9/2016

Biophysics of information processing in gene regulation, FWF-stand alone, €341'000, 1/2016-12/2018

UHLER GROUP

Gaussian Graphical Models: Theory and Applications, FWF-START, €985'000, 7/2015-6/2018

VICOSO GROUP

Sex chromosome evolution under male- and female-heterogamety, FWF-stand alone, €224'000, 1/2016-12/2018

WAGNER GROUP

Embeddings in Higher Dimensions: Algorithms and Combinatorics, SNSF-professorships, €174'000, 3/2013-6/2016

Robust invariants of Nonlinear Systems, FWF-Meitner fellowship,€160'000, 2/2016-1/2018

WOJTAN GROUP

Big Splash Efficient Simulation of Natural Phenomena at Extremely Large Scales, H2020 ERC Starting Grant, €1'500'000, 3/2015-2/2020

Deep Pictures: Creating Visual and Haptic Vector Images, FWF-stand alone, €226'000, 8/2012-7/2016

Japan Society for the Promotion of Science (JSPS), €79'000, 4/2014-3/2016

Akademia Gorniczo-Hutnicza Krakowie, €3'000, 11/2015-10/2016

AWARDS AND PRIZES 2015

Bernd Bickel	Microsoft Visual Computing Award
Johnathan P. Bollback	ERC Consolidator Grant "Selective Barriers to Horizontal Gene Transfer"
Sylwia Cremer	Elisabeth Lutz-Prize (Austrian Academy of Sciences)
László Erdős	Member of Academia Europaea
Jiří Friml	Erwin Schrödinger-Prize (Austrian Academy of Sciences)
Carl-Philipp Heisenberg	Member of Leopoldina
Thomas A. Henzinger	EATCS Fellow (European Association for Theoretical Computer Science), Milner Award 2015 (Royal Society)
Peter Jonas	Member of Academia Europaea
Anna Kicheva	ERC Starting Grant "Coordination of Patterning and Growth in the Spinal Cord"
Martin Loose	ERC Starting Grant "Self-Organization of the Bacterial Cell"
Gaia Novarino	Boehringer Ingelheim FENS Research Award, CURE Taking Flight Award
Krzysztof Pietrzak	ERC Consolidator Grant "Provable Security for Physical Cryptography"
Caroline Uhler	START Award (FWF Austrian Science Fund)
Chris Wojtan	Young Researcher Award 2015 (Eurographics), Günter Enderle Best Paper Award 2015 (Eurographics)

Communicating Scientific Results

Publications by IST Austria members published or accepted in 2015; joint publications involving several groups are listed multiple times.

BARTON GROUP

Barton N.H., and Servedio M.R., The interpretation of selection coefficients, Evolution, vol. 69, May 2015, 1101-1112.

Broadhurst L.M., Fifield G., Vanzella B., and Pickup M., An evaluation of the genetic structure of seed sources and the maintenance of genetic diversity during establishment of two yellow box (Eucalyptus melliodora) seed-production areas, Australian Journal of Botany, vol. 63, Jan. 2015, 455-466.

Cepeda Humerez S.A., Rieckh G., and Tkačik G., Stochastic proofreading mechanism alleviates crosstalk in transcriptional regulation, Physical Review Letters, vol. 115, Dec. 2015, Article number: 248101.

Friedlander T., Mayo A.E., Tlusty T., and Alon U.,Evolution of bow-tie architectures in biology, PLoS Computational Biology, vol. 11, Mar. 2015, Article number: e1004055.

Giacobbe M., Guet C.C., Gupta A.K., Henzinger T.A., Paixão T., and Petrov T.P., Model checking gene regulatory networks, TACAS: Tools and Algorithms for the Construction and Analysis of Systems, vol. 9035, Jan. 2015, 469-483.

Keller-Schmidt S., Tuğrul M., Eguíluz V.M., Hernandez-Garcia E., and Klemm K., Anomalous scaling in an age-dependent branching model, Physical Review E Statistical Nonlinear and Soft Matter Physics, vol. 91, Feb. 2015, Article number: 022803.

Novak S., and Cremer S., Fungal disease dynamics in insect societies: Optimal killing rates and the ambivalent effect of high social interaction rates, Journal of Theoretical Biology, vol. 372, May 2015, 54-64.

Paixão T., Badkobeh G., Barton N.H., Çörüş D., Dang D., Friedrich T., Lehre P.K., Sudholt D., Sutton A.M., and Trubenová B., Toward a unifying framework for evolutionary processes, Journal of Theoretical Biology, vol. 383, Oct. 2015, 28-43.

Polechová J., and Barton N.H., Limits to adaptation along environmental gradients, PNAS, vol. 112, May 2015, 6401-6406.

Priklopil T., and Chatterjee K., Evolution of decisions in population games with sequentially searching individuals, Games, vol. 6, Sep. 2015, 413-437.

Trubenová B., Novak S., and Hager R., Indirect genetic effects and the dynamics of social interactions, PLoS One, vol. 10, May 2015, Article number: e0126907.

Tuğrul M., Paixão T., Barton N.H., and Tkačik G., Dynamics of transcription factor binding site evolution, PLoS Genetics, vol. 11, Nov. 2015, Article number: e1005639.

Uecker H., Setter D., and Hermisson J., Adaptive gene introgression after secondary contact, Journal of Mathematical Biology, vol. 70, Jun. 2015, 1523-1580.

BENKOVÁ GROUP

Chen Q., Liu Y., Maere S., Lee E., Van Isterdael G., Xie Z., Xuan W., Lucas J.R., Vassileva V.N., Kitakura S., Marhavý P., Wabnik K., Geldner N., Benková E., Le J., Fukaki H., Grotewold E., Li C., Friml J., Sack F.D., Beeckman T., and Vanneste S., A coherent transcriptional feed-forward motif model for mediating auxin-sensitive PIN3 expression during lateral root development, Nature Communications, vol. 6, Nov. 2015, Article number: 8821.

Robert H.S., Crhák Khaitová L., Mroue S., and Benková E., The importance of localized auxin production for morphogenesis of reproductive organs and embryos in Arabidopsis, Journal of Experimental Botany, vol. 66, Aug. 2015, 5029-5042.

Šimášková M., O'Brien J.A., Khan M., Van Noorden G.E., Ötvös K., Vieten A., De Clercq I., Van Haperen J.M., Cuesta Moliner C., Hoyerová K., Vanneste S., Marhavý P., Wabnik K., Van Breusegem F., Nowack M.K., Murphy A.S., Friml J., Weijers D., Beeckman T., and Benková E., Cytokinin response factors regulate PIN-FORMED auxin transporters, Nature Communications, vol. 6, Jan. 2015, Article number: 8717.

Žádníková P., Smet D., Zhu Q., Van Der Straeten D., and Benková E., Strategies of seedlings to overcome their sessile nature: Auxin in mobility control, Frontiers in Plant Science, vol. 6, Apr. 2015, Article number: 218.

BICKEL GROUP

Bermano A.H., Beeler T., Kozlov Y., Bradley D.J., Bickel B., and Gross M.H., Detailed spatio-temporal reconstruction of eyelids, SIGGRAPH: Special Interest Group on Computer Graphics and Interactive Techniques, vol. 34, Jul. 2015, Article number: 44.

Bharaj G., Coros S., Thomaszewski B., Tompkin J., Bickel B., and Pfister H., Computational design of walking automata, SCA: ACM SIGGRAPH / Eurographics Symposium on Computer Animation, Aug. 2015, 93-100.

Klehm O., Rousselle F., Papas M., Bradley D.J., Hery C., Bickel B., Jarosz W., and Beeler T., Recent advances in facial appearance capture, Computer Graphics Forum, vol. 34, May 2015, 709-733.

Martin T., Umetani N., and Bickel B., OmniAD: Data-driven omni-directional aerodynamics, SIGGRAPH: Special Interest Group on Computer Graphics and Interactive Techniques, vol. 34, Jul. 2015, Article number: 113.

Pérez J., Thomaszewski B., Coros S., Bickel B., Canabal J.A., Sumner R.W., and Otaduy M.A., Design and fabrication of flexible rod meshes, SIGGRAPH: Special Interest Group on Computer Graphics and Interactive Techniques, vol. 34, Jul. 2015, Article number: 138.

Schumacher C., Bickel B., Rys J., Marschner S., Daraio C., and Gross M.H., Microstructures to control elasticity in 3D printing, SIGGRAPH: Special Interest Group on Computer Graphics and Interactive Techniques, vol. 34, Jul. 2015, Article number: 136.

BOLLENBACH GROUP

Angermayr A.S., Gorchs A.G., and Hellingwerf K.J., Metabolic engineering of cyanobacteria for the synthesis of commodity products, Trends in Biotechnology, vol. 33, Jun. 2015, 352-361.

Bierbaum V., and Klumpp S., Impact of the cell division cycle on gene circuits, Physical Biology, vol. 12, Sep. 2015, Article number: 066003.

Bollenbach T., Antimicrobial interactions: Mechanisms and implications for drug discovery and resistance evolution, Current Opinion in Microbiology, vol. 27, Oct. 2015, 1-9.

Bollenbach T., and Heisenberg C., Gradients are shaping up, Cell, vol. 161, Apr. 2015, 431-432.

Chevereau G., and Bollenbach T., Systematic discovery of drug interaction mechanisms, Molecular Systems Biology, vol. 11, Apr. 2015, Article number: 807.

Chevereau G., Dravecká M., Batur T., Guvenek A., Ayhan D.H., Toprak E., and Bollenbach T., Quantifying the determinants of evolutionary dynamics leading to drug resistance, PLoS Biology, vol. 13, Nov. 2015, Article number: e1002299.

De Vos M.G., Dawid A., Šunderlíková V., and Tans S.J., Breaking evolutionary constraint with a tradeoff ratchet, PNAS, vol. 112, Dec. 2015, 14906-14911.

Hammar P, Angermayr A.S., Sjostrom S L, Van Der Meer J, Hellingwerf K J, Hudson E P, and Joensson H N, Single-cell screening of photosynthetic growth and lactate production by cyanobacteria, Biotechnology for Biofuels, vol. 8, Nov. 2015.

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meeting room

Scientific Events

Conferences, Symposia, and Workshops

IST Austria is linked to the scientific community through a range of scientific events, from annual conferences to weekly seminars, including many interdisciplinary events.

IST Austria hosted a scientific workshop in March, which brought together six ERC-funded research groups in the area of formal verification, from Belgium, France, Israel, the UK, and Austria. The aim of the workshop was to exchange ideas and collaborate on research questions.

In April, the AIT-IST Collaboration Workshop provided a platform to gauge the interest in cooperations between research groups at the AIT (Austrian Institute of Technology) and IST Austria. Six research groups from each institute presented their work to explore possibilities for combining basic and applied research.

At the beginning of May, the postdocs and PhD students of IST Austria organized the fourth annual Young Scientist Symposium titled “Self-organization”. Self-organizing phenomena occur throughout a broad range of systems: from fluid dynamics and molecular self-assembly in the microscopic world to macroscopic phenomena such as the collective behavior of insects. The one-day multidisciplinary event consisted of five talks and a panel discussion on topics from biology, physics, and computer science.

Two symposia of the conference on Quantum Many-Body Systems, Random Matrices, and Disorder, held from June to July at the Erwin Schrödinger International Institute for Mathematical Physics (ESI) in Vienna, also took place at IST Austria. The program brought together leading experts in the mathematical analysis of many-body quantum systems and random operators/matrices to establish a framework in which new tools for dealing with these complex systems can be developed. The one-day symposia were jointly supported by ESI and IST Austria.

The Applied and Computational Algebraic Topology (ACAT) project funded by the European Science Foundation held its final project meeting in July. It focused on topological data analysis, stochastic topology, and topology of concurrency and distributed computing. While the core of the field is mathematical, it thrives on the interaction with other disciplines such as computing, neuroscience, biology, or materials science.

The 13th annual Austrian Proteomic Research Symposium (APRS) took place in August. It was organized in collaboration with the Austrian Proteomics Association (AuPA) and IMP/IMBA/GMI/CSF from the Vienna Biocenter. The purpose of the symposium was to present the latest technologies and applications in proteomics.

In September, IST Austria hosted the first European Conference on Axon Guidance, Circuit Development, and Regeneration (AXON 2015). With more than 160 participants, it was the largest scientific event held at IST Austria so far. The meeting provided a forum for the exchange of results and ideas in the rapidly advancing fields of nerve cell polarization, axon guidance, synapse formation, circuit assembly, and neuronal regeneration. There is increasing overlap among these disciplines and some of the most outstanding recent advances have been achieved by research at the intersection of these fields. By bringing together scientists working in these diverse areas — including the clinically relevant field of regeneration — new insights, collaborations, and new research directions were inspired.

Also in September, the yearly meeting of the EU FET-OPEN project “Silicon platform for quantum Spintronics” was held on campus. The SiSpin consortium consists of six research groups bringing together recognized European experts in the areas of growth, nanofabrication, low temperature electronic transport, and high frequency manipulation of spins in SiGe based materials. During the two-day meeting, the multi-disciplinary team discussed the progress made in quantum spintronics in the past year, drawing on very recent experimental, theoretical, and technological developments.

In December, the opening ceremony of the second period of the Doctoral Program “Ion Channels and Transports as Molecular Drug Targets” was held at IST Austria in collaboration with the University of Vienna. The symposium included talks by invited experts in the field as well as presentations by former and current students of the program. The event concluded with a panel discussion among the experts.

THE INSTITUTE COLLOQUIUM

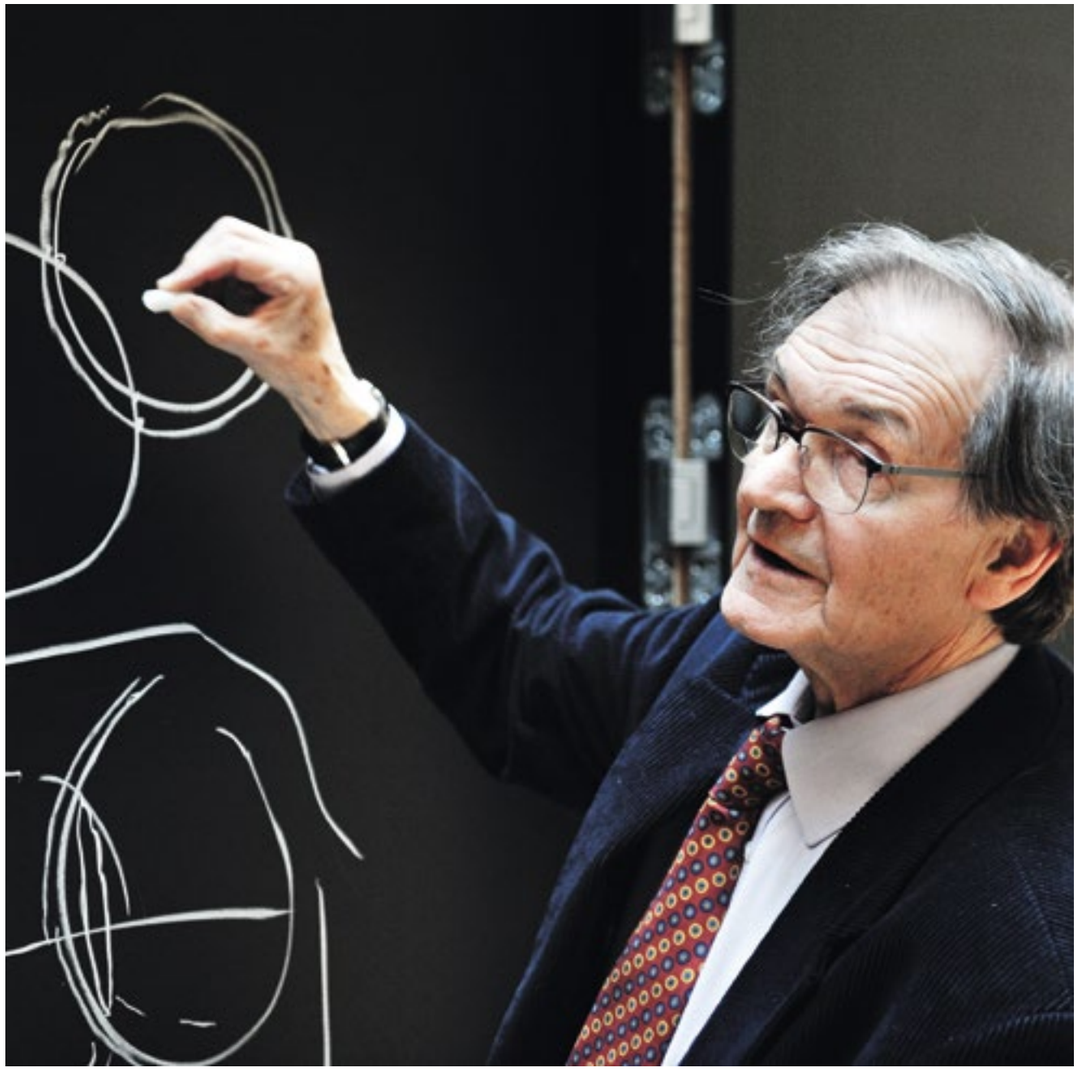
The IST Colloquium is the Institute’s main weekly seminar which addresses a broad range of topics in the fields of computer, mathematical, physical, and life sciences. Julie Theriot from Stanford University, Yves Barde from Cardiff University, and Jan Born from the University of Tübingen were among the many international experts to present their latest research in 2015. The IST Colloquium is open not only to the scientists on campus, but also to all scientists from the Vienna region.

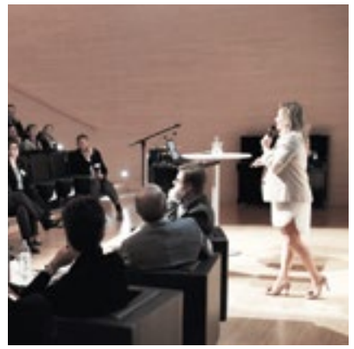
More information on the IST Colloquium can be found on the website *(www.ist.ac.at).*

If you wish to be added to the mailing list for IST Colloquia and other events, please subscribe on our website or send a request to *office@ist.ac.at.*

Public Events

Communicating Science





IST Austria aims to raise the public awareness of the importance of basic research and to foster an understanding for the natural sciences. The Institute organizes numerous community events on campus and participates in many regional events to reach out to the general public.

Almost 2'000 guests of all ages explored the campus grounds at the "Open Campus" on a beautiful spring day on May 31. After General Manager Georg Schneider welcomed the visitors at the opening ceremony, Lower Austria's Minister for Education Barbara Schwarz and Klosterneuburg's City Commissioner for Education Maria-Theresia Eder emphasized the importance of extracurricular activities such as the Open Campus. The visitors enjoyed the award ceremony of the school competition, the family lecture by IST Austria Professor Simon Hippenmeyer on "Functions of the Human Brain", and the tower building competition. Campus tours and research islands provided fascinating insights into the labs.

The Open Campus was followed by the Science-Industry Talk on June 2. At the event titled "Green Fields and Blue Sky", international business leaders and technology transfer experts discussed the necessary ingredients for a successful translation of basic research into commercialization. A keynote from Nava Swersky Sofer (former President and CEO of Yissum, the technology transfer company of the Hebrew University of Jerusalem) was followed by a roundtable with Tapio Siik (head of ACE Aalto Center for Entrepreneurship), Oliver Holle (CEO of Speedinvest), Monika Kircher (chair of the Committee for Research, Technology, and Innovation of the Federation of Austrian Industries IV), and Markus Wanko (IST Austria's head of technology transfer). The Science-Industry Talk series is organized in collaboration with the Federation of Austrian Industries to strengthen the relationship between industry and basic research.

In August, IST Austria turned into a summer camp for elementary school children. Thirty-five girls and boys aged 7–11 took their first steps into the world of science at the "Sommer Campus", supported by students of the University College of Teacher Education Lower Austria and IST Austria scientists. Research activities in physics, biology, and computer science were complemented by a scavenger hunt on campus and an excursion to the Wolf Science Center. The young scientists presented their work at the end of the week in an exhibition and proudly received their certificates at the final graduation ceremony.

IST LECTURES

IST Lectures are given by eminent scientists who are invited to present their research to the general public and the scientific community. Sir Roger Penrose's IST Lecture titled "Before the Beginning and Beyond Eternity" brought a record attendance on May 21 and was broadcast to an additional hall to accommodate the large audience. Moreover, it was the first IST Lecture that was streamed live on the internet and made available world-wide. In his lecture, Penrose — Emeritus Rouse Ball Professor of Mathematics at the University of Oxford — discussed cosmological theory and presented his model of a universe iterating through infinite cycles.

Scott Aaronson, a distinguished theoretical computer scientist at the Massachusetts Institute of Technology, gave an IST Lecture on "Computation Complexity and Fundamental Physics" to a full lecture hall on October 21. In his talk, Aaronson discussed how computational complexity theory — the study of what is and is not feasibly computable — can provide us with new insights into the nature of physical laws. He gave his personal view of quantum computing's key ideas, its current status and future prospects, and placed the attempt to build practical quantum computers in the broader context of the quest to understand the ultimate physical limits of computation.

Technology Transfer

Bridging Science and Industry

Lita Nelsen, head of MIT's Licensing Office, talked about technology transfer at IST Austria

TECHNOLOGY TRANSFER OFFICE - TWIST

The Technology Transfer Office is the one-stop shop for all matters related to intellectual property, industry relations, and entrepreneurship at IST Austria. It is responsible for patent protection and licensing, and supports the creation of spin-off companies and cooperation with industry. A range of measures is offered to translate research outcomes into product ideas which the Institute intends to commercialize through licensing and the support of start-ups. For instance, the TWIST fellowship program was initiated to support scientists interested in the commercial development of their research results. TWIST facilitates the exchange with industry, works with founders, and helps researchers make career decisions.

THE TWIST FELLOWSHIP PROGRAM

The TWIST fellowship program allows selected TWIST fellows to kick-start the development and translation of innovative technologies into commercially attractive assets. Fellows are supervised by the Technology Transfer Office staff guiding them through the business maze. The duration of a TWIST fellowship is limited to 12 months during which fellows are expected to acquire continuing funding by applying for public grants or by securing investment. TWIST fellows are selected by an expert panel consisting of Oliver Holle (speedinvest), Gottfried Himmler (theantibodylab), Markus Wanko, and IST Austria Professors Herbert Edelsbrunner and Harald Janovjak.

INTELLECTUAL PROPERTY

In 2015, IST Austria filed four patents, which is a notable achievement for an institution of this size and age. Three filings come from Professor Harald Janovjak's group: One patent relates to an innovative drug screening method based on optogenetics; a second patent concerns a compound to treat a specific type of non-small cell lung cancer; and the third describes a potential new method for treating type I diabetes in the form of a light-based treatment to increase cell proliferation of pancreatic beta cells. The fourth filing was on a new method developed by Professor Björn Hof and his team on relaminarization of turbulent flow in a duct.

IST PARK

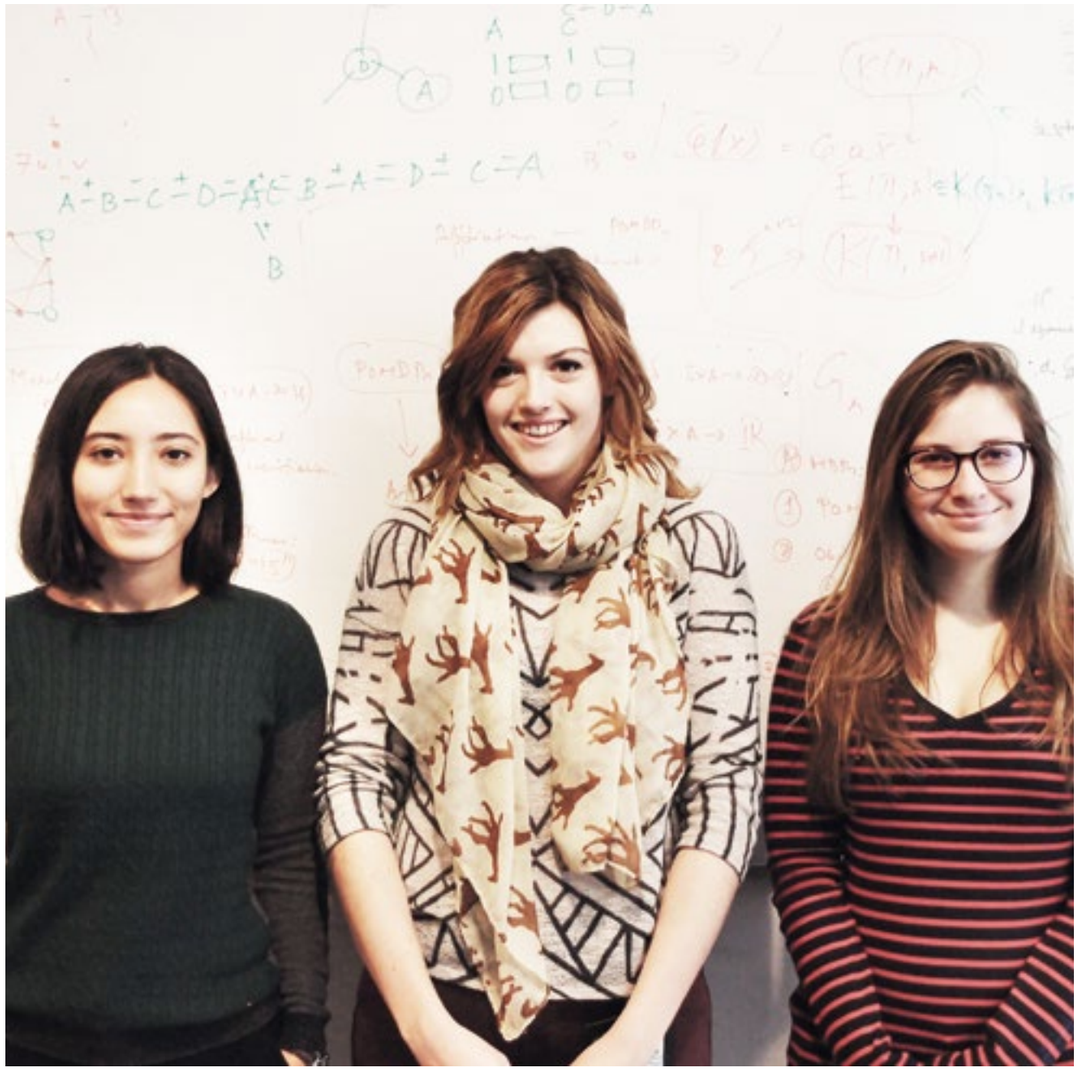
The project to build a science and technology park for research-intensive enterprises adjacent to the IST Austria campus moves ahead. The joint development company between ecoplus — the business agency of Lower Austria — and IST Austria has secured sufficient commitments to start the planning and construction of the early development phase. The completion of the first buildings is expected for 2018. Until then, IST Austria rents out office space in the newly inaugurated Lab Building West to future residents of the tech park. The first tenant is PRIME Aerostructures, a company active in the design, modelling, and simulation of aircraft components.

TWIST FELLOW NEWS: CONTROLLING TURBULENT PIPE FLOW

The first TWIST fellow Markus Schaner started in November 2015. He works with co-inventor Jakob Kühnen on a technology for the relaminarization of turbulent flows, which is an output of Professor Björn Hof's lab: In nature as well as in industrial applications, two fundamentally different states of flow can be observed, namely laminar and turbulent flow. In contrast to laminar flow, where the fluid moves in smooth layers, turbulence is characterized by huge and rapid fluctuations and strong swirling motions. Thus, turbulence is responsible for a drastic increase in frictional drag, heat transfer, and fluid mixing. It is the major cause of energy losses in fluid transport. In pipes, laminar flow is typically realized only when flow speed is low. Professor Hof's group has developed a novel and efficient technique to modify the velocity profile by using stationary flow management devices. These devices allow for the relaminarization of fully turbulent pipe flow up to a Reynolds number of 10'000, which leads to a drastic reduction of drag, heat transfer, and fluid mixing. In collaboration with the Lauder Business School, Markus Schaner investigates the market for this technology.

Donors

Fostering Frontier Research



STAKEHOLDER RELATIONS

The newly established department Stakeholder Relations combines IST Austria's fundraising activities. The main objectives of this department are to identify and maintain relations with individuals, enterprises, and networks that are interested in supporting the development of IST Austria. Oliver Lehmann is the head of Stakeholder Relations.

A NEW CULTURE OF PHILANTHROPY

The Institute is committed to strengthening its independence by raising third-party funds from a variety of sources. IST Austria's scientists are extremely successful in the acquisition of competitive research grants which, combined, have surpassed the threshold of EUR 50 million in 2015. While fundraising for basic science from private donors is still a new culture in Austria, the Institute is committed to excel also in this form of philanthropy. This effort is also encouraged by the federal government, which doubles all donations — up to a threshold value — until December 31, 2016.

Until the end of 2015, IST Austria has already managed to attract donations amounting to EUR 17.5 million from various sources, including a EUR 10 million donation by Austrian entrepreneur Peter Bertalanffy in 2010. Named scholarships, professorships, or buildings serve as a means of recognition to thank IST Austria's network of supporters for their strong commitment to excellence in research and the education of future generations of scientists.

PÖTTINGER SCHOLARSHIPS

The most recent donation of EUR 200'000 was generously pledged by Klaus Pöttinger — co-owner of Pöttinger Agricultural Technology — and funds three PhD scholarships. The three students, who were selected by an IST Austria jury of postdocs, started their doctoral studies in 2015. The Pöttinger gift is already the third private donation for scholarships, following OMV and Steven Heinz. A total of nine PhD scholars have been announced to date. These donations have a very positive impact on the young researchers who appreciate the benefits of the scholarship, as their statements show:

"Receiving the Pöttinger scholarship makes me one of the representatives of our graduate program. Being a recipient shows me the trust of my colleagues in my future success and reminds me of my responsibilities towards society as a scientist. This motivates me to keep high standards in my research."

Feyza Nur Arslan
PhD student 1st year

"Winning a scholarship at IST Austria was really a great surprise. It was very encouraging to know how business people like Mr Pöttinger feel about fundamental research and supporting young scientists. Having this external source of motivation and support will surely be of great help for the years to come."

Matilda Peruzzo,
PhD student 1st year

"The Pöttinger scholarship allows me to focus my studies on new topics which I can apply towards my work as a scientist. By letting me study the mechanisms of stem cell differentiation, it motivates me to pursue a career in academia."

Priscila Pichani Hirschfeld
PhD student 1st year

IST AUSTRIA DONORS CLUB

Platinum Club
Invicta Foundation

Gold Club
Mondi AG
OMV AG
Raiffeisen Group
voestalpine AG

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Berndorf AG
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DI Klaus Pöttinger

Donor Club
Alcatel-Lucent Austria AG
Gebrüder Weiss GmbH
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Administration

Excellent Service for Excellent Science

The mission of IST Austria's administrative staff is to provide the best possible environment for outstanding science. In five major divisions, dedicated experts offer their assistance on a wide range of topics:

Academic Affairs: The division takes care of all administrative aspects of academic matters. The team coordinates the quality control of research at the Institute, manages the entire recruitment process for professors, and coordinates meetings of the Scientific Board, the Professorial Committee as well as various kinds of evaluations. The Graduate School Office is responsible for the organization of the PhD program and academic courses, as well as the admissions and progress-monitoring processes for students.

Communication & Events: The team provides services in media relations, scientific writing, web and social media management, alumni relations, event management, public outreach activities, and science education.

Construction & Maintenance: The division manages the buildings and facilities on campus, including electricity, heating, ventilation and air-conditioning. An associated unit is Environment, Health & Safety to safeguard these fundamental aspects.

Finance & Operations: The team is responsible for accounting, controlling, and procurement. The Grant Office as part of the division informs scientists on funding schemes and assists with writing proposals and the administration of approved grants.

Human Resources: Beyond classic HR tasks, the services range from hospitality, assistance to foreign employees through the international office, gender & diversity to dual career advice. The division also includes Campus Services — a unit that manages a variety of topics from food to housing, transportation, and sports facilities on campus.

In addition to these main divisions, specialized tasks are accomplished by a number of units, such as Executive Affairs (including Organization, Process & Project Management, Legal Affairs, and Stakeholder Relations), Technology Transfer, and Campus IT Services.

GRADUATE SCHOOL OFFICE

A primary goal of IST Austria is the education and training of future generations of scientists. The Institute's Graduate School follows the model of the American research universities. Promising applicants to the PhD program are admitted centrally and select their PhD supervisors only after a year of rotation projects and a unique interdisciplinary course program (see also the doctoral training program ISTScholar on page 17).

Since the first call for PhD students in 2010, the number of students has risen from seven to 121 at the end of 2015 in just six years. This rapid development has been overseen by the Graduate School Office — the key unit for all matters related to the Institute's PhD program. The Graduate School Office is responsible for the organization of the PhD program and academic courses, as well as the admissions and progress-monitoring processes for students. The team promotes the PhD program at international career fairs and organizes the annual Student Open Day so that potential students can get to know the professors and fellow students on campus.

As the Institute grows and adds new research fields, so does the PhD program. In 2015, the PhD curriculum was adapted and now offers six tracks in physics, biology, neuroscience, mathematics, computer science, and computational & data science, and each track is supervised by a member of the faculty. The year 2015 also saw two premieres: Professor Nick Barton was appointed as first Dean of the Graduate School, and Hania Köver took over the new position as head of the Graduate School Office.

"The Federal Ministry of Science, Research, and Economy and the State of Lower Austria commissioned a financial and administrative review, which was carried out by a consortium consisting of PwC, Drees & Sommer, and technopolis from May 2014 until January 2015.

In their final report, the evaluators concluded that IST Austria is a well-organized internationally oriented research institute. They commend IST Austria on having been run economically since its foundation, and concluded that the Institute is on its way to becoming an exemplary model for cutting-edge research and science management alike.

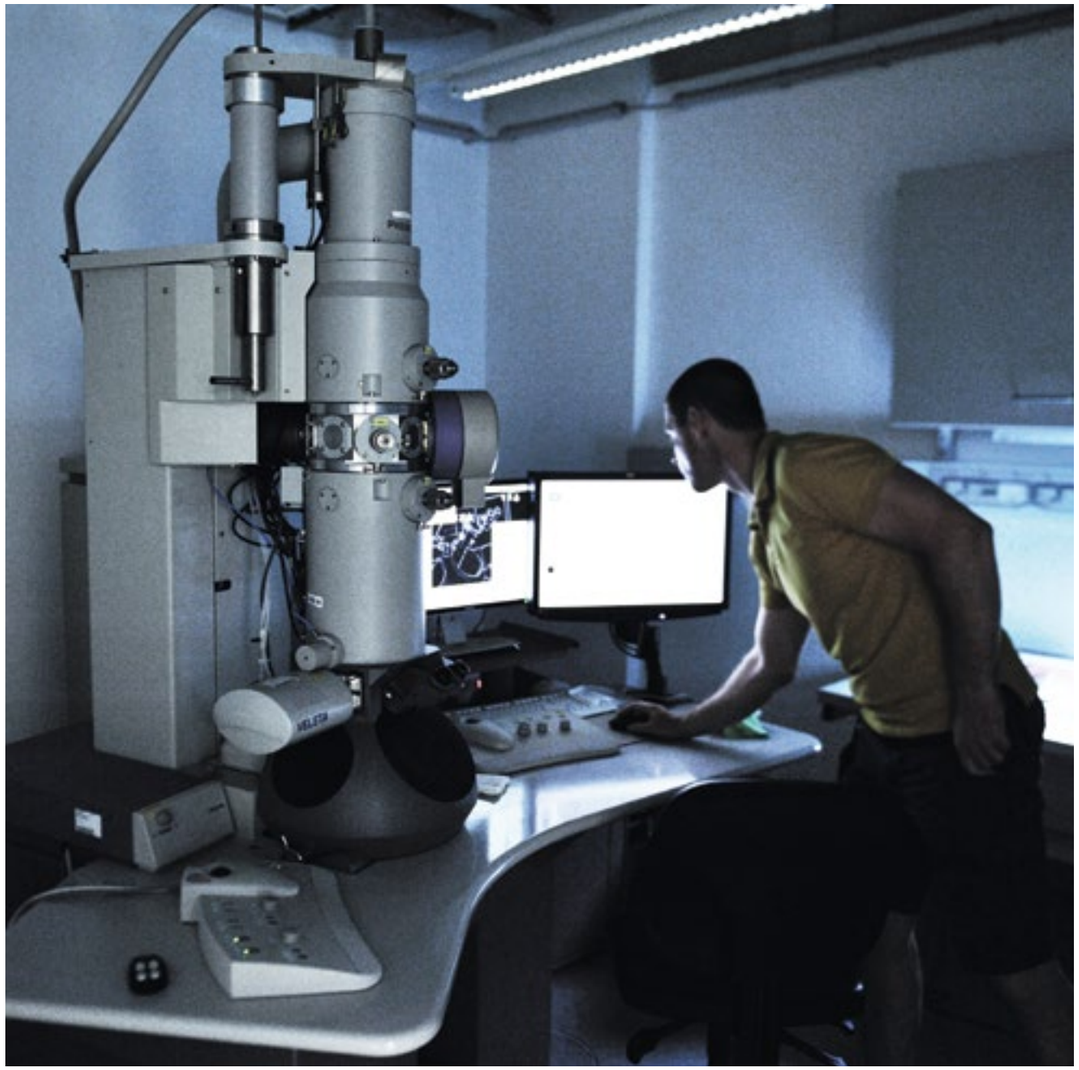
Additional highlights from the report include: IST Austria's scientific development plan corresponds well with the financial framework provided by the Republic of Austria and the State of Lower Austria for the development of IST Austria until 2026. Construction of the campus is proceeding according to the time and financial targets. The Institute's management is well organized and provides a professional and goal-oriented foundation for continued dynamic growth of the institute.

The positive evaluation report is an important recognition for IST Austria's successful path and encourages us to keep improving our approach to science management."

Georg Schneider,
Managing Director, IST Austria

Scientific Service Units

Shared Scientific Resources and Services



"The Scientific Service Units (SSUs) at IST Austria support researchers with know-how, infrastructure, technical support, routine services, and training. The seven facilities act as an interdisciplinary platform that maximizes the sharing of resources among the research groups. Since their establishment in 2009, the SSUs have continuously expanded their range of services to stay in line with the growth of IST Austria and its research scope. In 2015, a new SSU was established to meet the needs of experimental physics groups who are joining IST Austria: a state-of-the-art Nanofabrication Facility in Lab Building West will become fully operational in 2016 and provide support in micro- and nanofabrication processes. As dynamic and service-oriented facilities, the SSUs are a key asset for IST Austria in terms of research support and faculty recruiting."

Michael Sixt,
Vice President, IST Austria

The Scientific Service Units at IST Austria provide shared scientific support to researchers at the Institute. Set up in 2009, the Scientific Service Units have since grown to more than 60 employees in seven facilities. Their aim is to provide know-how and service for cutting-edge research at IST Austria through central acquisition, customized development, and training. Scientific Service Units and their infrastructure may be used by any research group, providing methodological state-of-the-art and facilitating interdisciplinary research at IST Austria. To promote the cost-effective and innovative use of equipment, Scientific Service Units cooperate with similar facilities at other research institutes and universities in and around Vienna.

As of the end of 2015, seven Scientific Service Units have been established at IST Austria:

Bioimaging Facility: The Bioimaging Facility supports cell biologists with state-of-the-art microscopes and flow cytometry equipment.

Electron Microscopy Facility: The Electron Microscopy Facility provides electron microscopes, as well as sample preparation and image analysis facilities for the life sciences and, in the future, physics and chemistry.

Nanofabrication Facility: The Nanofabrication Facility develops, optimizes, and maintains micro- and nanofabrication processes for experimental physics.

Library: The mainly electronic library licenses eJournals and eBooks and provides access to important databases and other electronic content.

Life Science Facility: The Life Science Facility supports experimental biologists by providing a laboratory infrastructure for the biological sciences and supplying experimental resources.

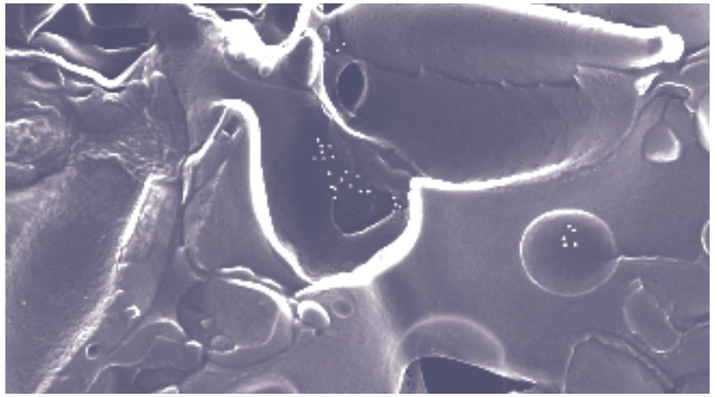
Miba Machine Shop: The Miba Machine Shop produces and provides non-conventional mechanical and electronic equipment for all experimental research groups, particularly in the neurosciences.

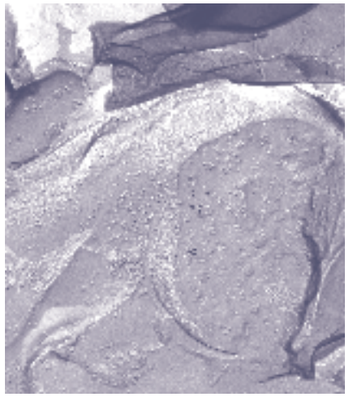
Scientific Computing: Scientific Computing supports theoretical and experimental researchers for all scientific computing needs, mainly by providing a high-performance computing cluster.

IST Austria's Electron Microscopy Facility

The air-conditioning hums monotonously as researchers sit in front of an array of big screens and countless round controllers in the Electron Microscopy Facility. In the four windowless rooms in the basement of Lab Building East, scientists accelerate electron beams with thousands of volts and smash them into precious samples. All to discover their tiniest details: nanometer-sized vesicles on the surface of nerve cells, single facets of fruitfly eyes or individual gold atoms covering a tiny electrode.

While light microscopes use light beams to magnify small details of down to 200 nanometers, electron microscopes use a beam of fast electrons to illuminate and look at even tinier structures of down to 150 picometers. The Electron Microscopy Facility at IST Austria provides users with four different microscopes: one scanning electron microscope (SEM) and three transmission electron microscopes (TEMs). Ludek Lovicar, manager of the





Electron Microscopy Facility, explains why the facility provides the different microscopes: “Two of our transmission electron microscopes are relatively easy to use and are the ‘workhorses’ of our facility. The other two microscopes are high-end products. These systems were set-up and used in Europe for the very first time when we installed the Jeol JEM 2800 in 2013 and the FE-SEM Merlin VP Compact together with the ATLAS Array Tomography tool in 2014 at IST Austria.”

The facility’s **scanning electron microscope** combines an automated sample collection system, the ATUMtome, with a hardware/software solution called ATLAS Array Tomography that automatically collects images. The ATUMtome cuts a sample into ultrathin sections of usually 70 nanometers. The automatically collected samples are stuck on tape and placed on a CD-like 4 inch silicon wafer. In the SEM, an FE-SEM Merlin VP Compact, the electron beam scans the surface of these sections in a raster. With ATLAS Array Tomography, microscope users can select a particular segment of their sample. The SEM then scans the segment of interest in each section on the wafer and reconstructs it to get a volume. IST Austria was the first research institute in Europe to acquire this combined system. Currently, it is mainly used by the group led by Ryuichi Shigemoto to study the interface of nerve cells and, by Michael Sixt’s group to study the lymph node system. But as Ludek Lovicar explains, more and more applications for the system are being explored: “To support cutting-edge research, we aim to realize the system’s fullest potential.”

The most powerful microscope in the EM facility is the **transmission electron microscope** Jeol JEM2800. In a TEM, the beam of electrons passes through the sample similar to an old film projector projecting light through film. The way the sample scatters or absorbs the electrons results in the image the microscope records. The Jeol JEM2800 at IST Austria can resolve structures below 1.5 Angstrom, which means that scientists can observe the atomic structure of their samples. With an additional scanning option, it can be used both as transmission and scanning transmission electron microscope. The Jeol JEM2800 is mainly used for volume reconstruction through tomography. In this mode, the unusually thick sample slices of up to 450nm are tilted in the electron beam. By imaging the slice in several tilt positions, its volume can be reconstructed at very high resolution. Currently, the Jeol JEM 2800 is mainly used to study brain tissue and synapses, but it is planned to be used also for investigating protein structures in other tissues. As the microscope can be coupled with element analysis, the EM facility expects future applications at IST Austria in both physics and chemistry.

For many current applications at IST Austria, the other two transmission electron microscopes in the EM facility, a TEM Tecnai 10 and a TEM Tecnai 12, are sufficient and therefore highly cost effective options. With these two workhorses, researchers at IST Austria investigate a wide range of questions and study structures such as those found in fruitfly embryos, lymph nodes of mice, the plant Arabidopsis or zebrafish embryos. Preparing such samples for microscopy and analyzing the resulting picture is a very time-consuming affair, and the employees at the Electron Microscopy Facility — Vanessa Zheden, Lisa Königsmaier, Walter Kaufmann, and Ludek Lovicar — support and guide users through all the steps.

Right image: Transmission electron micrograph of a replicated synapse showing the co-localization of (i) Cav2.1 voltage-gated calcium channels immunolabeled with the smaller 10-nm immunogold conjugates in the active zone of a parallel fiber synapsing with the dendritic spine of a Purkinje cell and (ii) RIM2 a protein of the cytomatrix immunolabeled with the larger 15-nm immunogold conjugates. While part of the axon terminal is cross-fractured revealing several synaptic vesicles, the remaining part is fractured at the protoplasmic membrane face.

Left image: Scanning electron micrograph of replicated hippocampal tissue showing the clustering of BK-type calcium-activated potassium channels immunolabeled with 10-nm gold conjugates at aspects of CA1 pyramidal cells. Immunolabeling is detected at the plasma membrane P-face (protoplasmic side) while the extracellular E-face is free of any immunolabeling.

Location & Directions

1 Central Building
Science Offices, Guesthouse, Oberbank Ballroom, Mondi Seminar Center, Cafe/Pub/Restaurant
2 Raiffeisen Lecture Hall
3 voestalpine Building
4 Bertalanffy Foundation Building
5 Preclinical Facility Building
6 Lab Building East
9 Memorial
11 Facility Management
12 Heating Plant
13 Miba Machine Shop
16 Power Control
21 Lab and Office Building West
27 Kindergarten
31-35 Apartments
41 Tennis Courts
42 Soccer Field