ISTA
Institute of Science and Technology Austria

Annual Report 2022

Building Bridges between Disciplines

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Contents

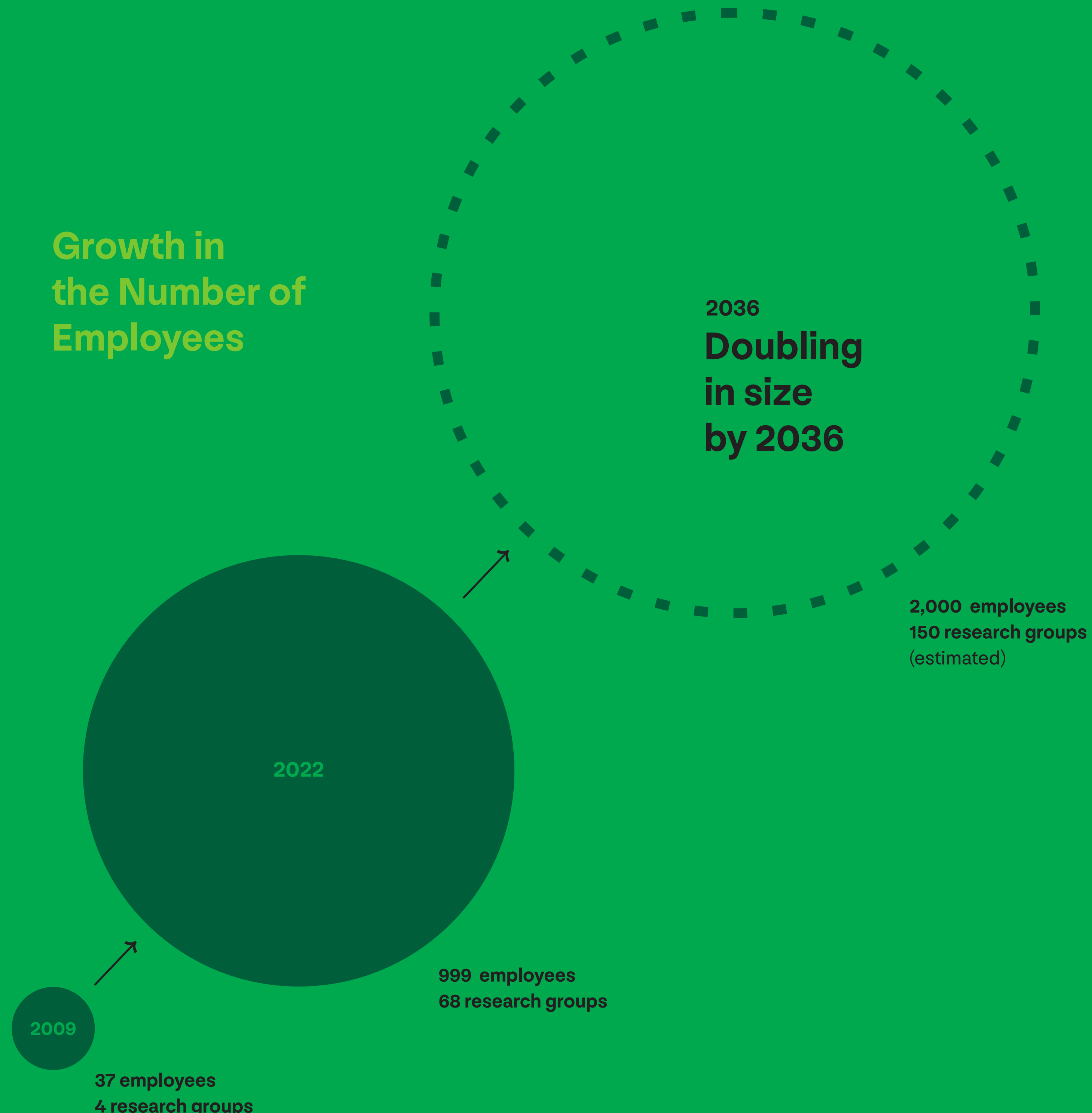
At a Glance

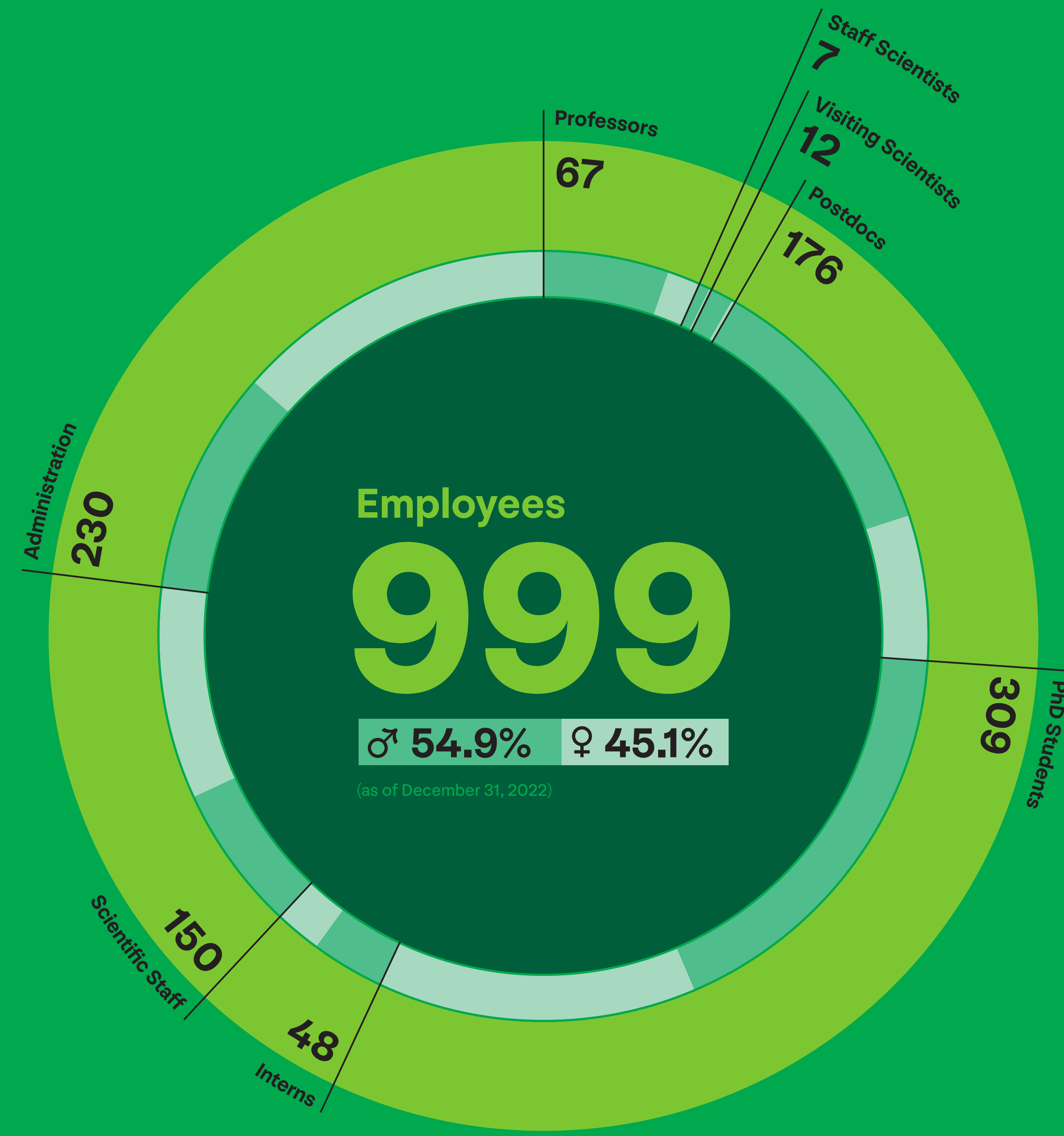
The Institute of Science and Technology Austria (ISTA) is a PhD-granting science institution dedicated to cutting-edge basic research. Founded in 2006 and joined by the first scientists in 2009, ISTA began as an ambitious experiment and has since grown into a flourishing institute.

77

Nationalities Working at ISTA

Growth in the Number of Employees





Pivate Funding in 2022

€ 30,000,000+

€ 52,000,000: Total from 2009 to 2022

€ 25,000,000: Largest single donation in ISTA history from Magdalena Walz in 2022

Professors at ISTA

Recruitment since 2009

Total number of international applications and nominations for professorships

16,791

553 Invited to campus

130 Offers made

67 Professors

Recruitment in 2022

1,229 Number of applications
47 Invited to campus
12 Offers made
8 New contracts, starting 2023

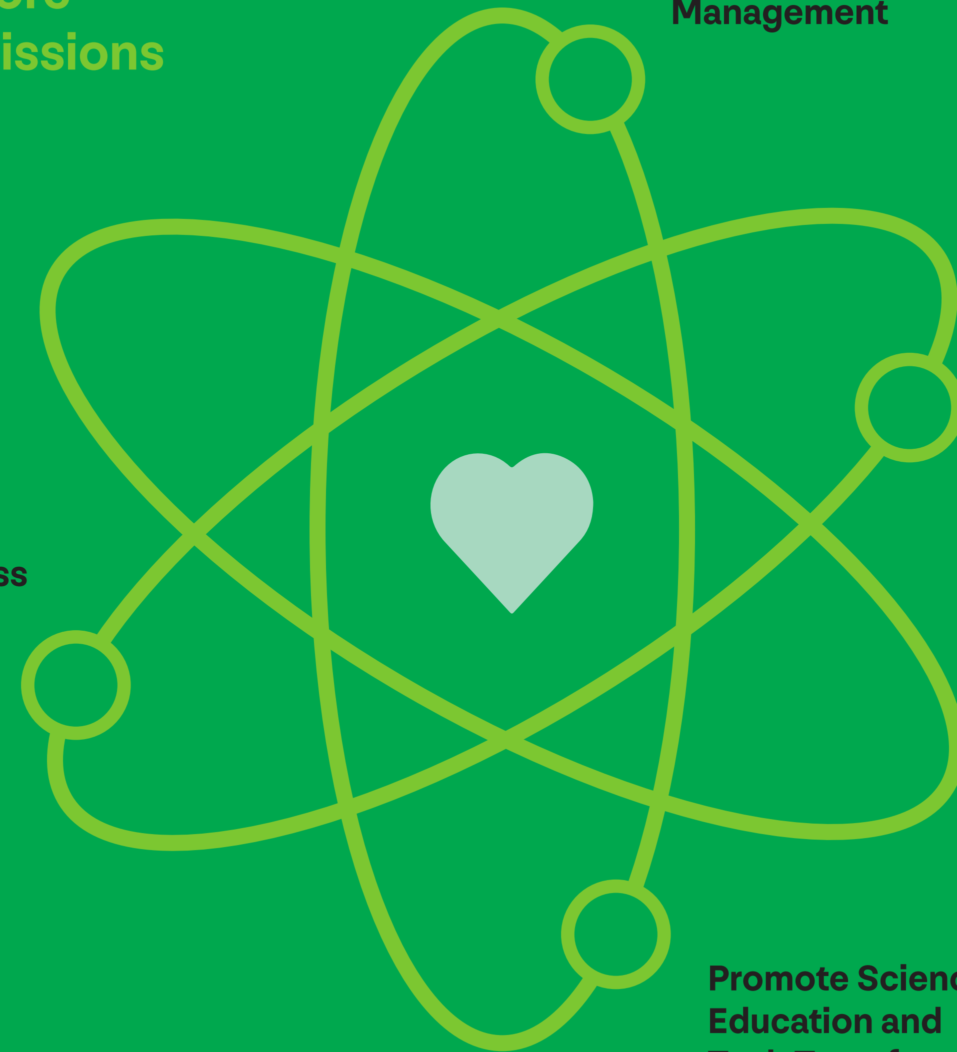
47 ERC grants 2009–2021

57 ERC Grants

Including proof of concept ERCs, excluding ten transferred to ISTA

10 ERC grants in 2022

Core Missions



Implement Best Practices in Science Management

Train the Next Generation of Scientific Leaders

Promote Science Education and Tech Transfer

Perform World-class Research

Founding Principles

Under the leadership of founding President Thomas A. Henzinger and future President Martin Hetzer, the Institute remains committed to its founding principles and core missions.

Diverse Funding
Public and Private

Basic Research
Curiosity-Driven

Exploiting Results
Intellectual Property

PhD Granting
Graduate School

Supporting Careers
Tenure Track

Multi-disciplinary
One Campus

International
Working Language English

Independent Boards
Guidance and Advice

Foreword

Bridges to the Future

This is my last year as President of ISTA. When I accepted the position in 2008, I promised to ensure that the characteristics that would attract me to an institution as a professor would never be negotiable at this institute, no matter how challenging this pledge would become. These characteristics include absolute freedom for scientists, global recruiting of world-class colleagues and students, arduously high standards and aspirations, and constant comparison with the most successful research institutions in the world. I am proud that we have upheld these principles, and I especially wish to thank Executive Vice President Michael Sixt and Managing Director Georg Schneider for their long-term support. This year alone saw the confirmation of many of ISTA's fundamental principles, and I am elated to end my tenure on this high note. External funding is a clear vote of confidence. The year 2022 was a banner year for ISTA in this regard: 25 million Euro from the Lower Austrian entrepreneur Magdalena Walz and 5 million Euro from the Austrian company Verbund AG. These two donations represent the start of an ambitious capital campaign aimed at building an endowment that will contribute to the financing of ISTA in perpetuity. In research awards, ten faculty members received grants of the European Research Council (ERC) in 2022, affirming the success of our careful recruiting process. The faculty hiring this year is also notable because half of the eight newly recruited professors are women. Together with the 67 current professors and circa 1,000 employees, this marks the halfway point towards our long-term target of 150 research groups by 2036. The ebbing pandemic permitted a gradual return to normal, including an in-person graduation ceremony and summer research interns. However, the Institute still feels the effects of the heinous Russian war and November's cyberattack. Both the ongoing misinformation warfare and the pandemic brought to the foreground and amplified a widespread lack of trust in science. At ISTA, we have made it part of our core mission to build bridges with the public. Such connections are important for calling out misinformation, as was discussed at the Institute's first Science Communication Day. We also seek to build bridges between basic research and industry. The vibrant technology park adjacent to campus now hosts more than a dozen companies—several with an ISTA connection—and over 100 employees; its expansion is already being planned. In September, the park was connected to the campus by the Michael Gröller Bridge, a futuristic landmark and a strong symbol of the impact our research has on society. It was more than two decades ago that Anton Zeilinger, one of this year's Nobel laureates, laid a crucial foundation for tomorrow's quantum technologies and, independently, lit the spark that eventually became ISTA. His conviction in the importance of curiosity-driven research and his belief in the potential of an excellence-oriented research institute in Austria led to the foundation of ISTA. Our employees—scientists and non-scientists alike—turned the vision of Zeilinger and the other founders into a shining reality. The success of this project was not a forgone conclusion; it took the hard work and unwavering commitment of everyone involved, from the employees and boards to our external supporters and the stakeholders in the federal and Lower Austrian governments. I thank all of you, also that I can now reap the benefits and become myself a professor at ISTA, focused solely on my science, under the new leadership of Martin Hetzer. I very much look forward to this change and have great confidence that ISTA will continue to flourish on its steadfast path towards international prominence.

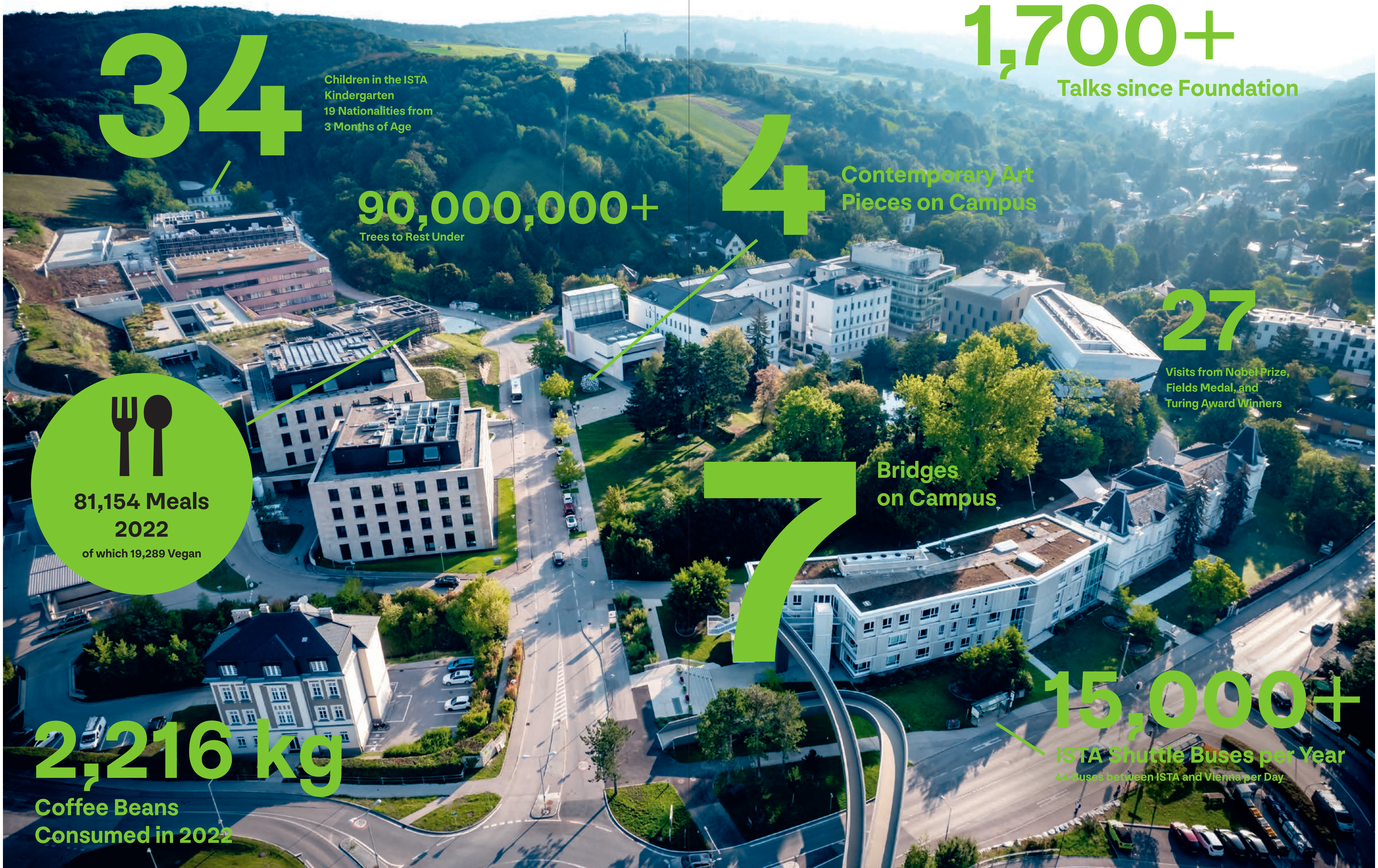
Thomas A. Henzinger
President 2009–2022

The campus has greatly expanded since the first buildings were inaugurated in 2009, and the rapid growth will continue. Planning for the next cluster of science buildings has begun and by the mid-2030s, the campus will employ more than 2,000 people, increasing both our scientific and our environmental impact. We are therefore increasing our sustainability efforts and are investing in the digitalization of our processes to ensure sustainable growth. Our great success so far has only been possible thanks to the tireless efforts, support, dedication, and passion of all members of the ISTA community.

Georg Schneider
Managing Director

Two things are essential for the infrastructure of ISTA's Scientific Service Units (SSUs). First, sufficient funding. The generous SSU budget ensures that we can invest in new machines, but also—equally important—that we can renew the equipment already on campus. Second, the ability to make use of these funds, when and for what we needed them. Under the leadership of President Henzinger, the SSUs have benefited greatly from the freedom and flexibility he granted us. From the very beginning, the process of acquiring new infrastructure at ISTA was entirely bottom-up and driven by the scientists.

Michael Sixt
Executive Vice President



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Children in the ISTA Kindergarten
19 Nationalities from 3 Months of Age

90,000,000+

Trees to Rest Under

81,154 Meals 2022

of which 19,289 Vegan

2,216 kg

Coffee Beans Consumed in 2022

1,700+

Talks since Foundation

4

Contemporary Art Pieces on Campus

27

Visits from Nobel Prize, Fields Medal, and Turing Award Winners

7

Bridges on Campus

15,000+

ISTA Shuttle Buses per Year

44 Buses between ISTA and Vienna per Day

Interview

From President to President

ISTA Timeline

↗ Anton Zeilinger suggests establishing an outstanding basic research institute in Austria

2002

↗ ISTA is founded
↗ First meeting of Board of Trustees
↗ Haim Harari leads development of the Institute

2006

↗ First employee hired

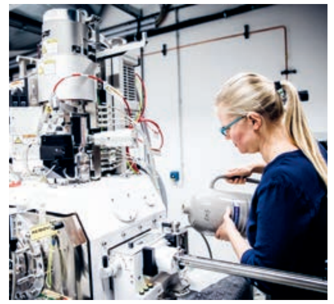
2007

↗ Thomas A. Henzinger starts as first president
↗ First four research groups move to campus
↗ 37 employees

2009

Halfway between the campus opening in 2009 and the planned expansion goal of 2036, a new president has been appointed, succeeding the founding president. The outgoing President Thomas A. Henzinger met the incoming President Martin Hetzer for a stroll around ISTA to exchange ideas on how to build a leading research institution, master the challenges of growth, and make an ambitious vision become reality.

Martin Hetzer: Tom, after more than 14 years as president you are handing over the position. How do you feel?
Thomas A. Henzinger: Good! It is time. Next year, I will likely have mixed feelings—I'm told. At age 60, it's probably the last opportunity I'll have to think about what I want to accomplish in research.
Martin: And research is what you love ...
Tom: Absolutely I will not go away but stay a professor at ISTA. And the transition is also good for the Institute—another person brings in fresh ideas and a new perspective. A change should not happen too often but not too seldom either.
Martin: If you think about the past 13 years, what are your personal milestones? What are you especially proud of?
Tom: I would have a hard time naming one or even three things. I am obviously extremely happy and satisfied with how everything turned out. At the end of 2008, when I took the job, I knew this was a high-risk project. Looking back, maybe I would have taken a few individual decisions differently, but overall, the scenario that has become a reality is one I could have only dreamed about all those years ago. We made many right decisions where we could have gone wrong.
Martin: To me, it is remarkable how closely the Institute resembles the original founding document.
Tom: By and large: Yes! In 2008, I talked to the chief architect of this institute, Haim Harari. One of the reasons I took the job—against, I must admit, quite a bit of advice—was because of a shared vision. Call it Haim's vision, call it my vision—they were amazingly aligned. This is also the reason why we stuck to it so much. The founding vision acted like the constitution of the Institute. We took many small decisions along the way, but we were always clear about the direction.
Martin: I see the Institute as an enormous success and everyone objectively sees it that way, ones who know the



↗ Opening: Bertalanffy Building, the first ISTA laboratories
↗ Start of Bioimaging Facility
↗ First PhD student

2010

↗ First annual Open Campus
↗ Opening: Preclinical Facility

2011

↗ Opening: Lab Building East
↗ First PhD graduation ceremony
↗ 100th employee

2012

↗ Start of the Electron Microscopy Facility
↗ First patent filed on campus

2013

Institute and also those that don't know it well. I see ISTA kind of like a 13-year-old teenager.
Tom: A gifted teenager!
Martin: What were your biggest challenges?
Tom: I underestimated how managing an institution becomes more complex with size. I now have great respect for governments. It is enormously complicated to run large entities—especially a system with many different constituents. No institution can be completely democratic; some decisions simply have to be taken at some point. Still, you want to bring on board the whole institution and this is vastly more complicated with a thousand employees than it was with a hundred.
Martin: I thought of this from the administrative side as a complex system. Organizations are not complicated, they are complex. It is common to look at organizational charts as if an institution is a complicated machine; if something doesn't work then you replace a part. But there is a difference in science between "complicated" and "complex". Complex often means that there are non-linear challenges. A plus B doesn't always give C. Every decision has unintended consequences. Of course, we always aspire to anticipate complexity. I enjoy this complexity in my job but I also deeply share that it can be too big a task on a day-to-day basis. I'll walk into this challenge with open eyes on how all the pieces fit together.
Tom: And, Martin, ISTA will double in size.
Martin: Well, good that we have this walk then. What is the vision for 2036, Tom?
Tom: There is one thing that I am absolutely convinced about, without which the institute cannot be successful. It is simply about hiring fantastic scientists. In the end, we choose scientists on every level from student to professor. Quality before speed, person before area. We need to continue to choose wisely. Not every decision will be right, but overall, this is in many ways the most important thing. Everything else can be put in place to make the Institute work. The quality of scientists is crucial. Martin, you are taking over the Institute. It's still very young but has already achieved quite a bit. How do you feel about it?
Martin: Very, very excited. I knew about ISTA because I always stayed in touch with the research landscape in Europe. I am humbled by the opportunity to be your successor and lead this vibrant and innovative institution, where the contributions of 1,000 scientists and staff have helped build its well-deserved reputation as a pioneer in international science. Like you, I also see enormous potential. It's an opportunity not only for the Austrian scientific landscape but certainly for Europe and also internationally. ISTA can compete with top institutions as it is now. But with the backing it has received from the Lower Austrian government for its further expansion … I don't know any other institute—even internationally—that has that perspective right now.
Tom: Is this why you are moving from California to Klosterneuburg?
Martin: Honestly, becoming President of ISTA is the most exciting job in international science right now. There is nothing else that has this great combination of enormous potential, achievements, the committed resources, and also the space to expand. And I'm excited just for that fact alone. I also feel a weight of responsibility on my shoulders. I'm sure you felt it too. Many people's hopes and dreams depend on how well the Institute continues to grow. I am very much aware that there are many things we have to address for this young institute to mature. If we as a team continue to make many good decisions, then this institute has many decades, potentially centuries ahead to become one of the top institutes in the world.
Tom: You have seen ISTA from abroad. How is the Institute looked at from there and how did you perceive it from the beginning?

↗ 400th employee
↗ First annual Summer Camp

2014

↗ Opening: Lab & Office Building West
↗ Founding xista Tech Transfer

2015

↗ Opening: Cafeteria
↗ Start of the Nano-fabrication Facility
↗ Founding seed fund xista Science Ventures

2016

↗ Opening: Administration Building

2017

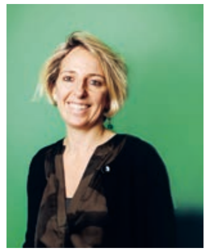
Martin: You might remember that I met you together with Michael and Georg in the US when you were on a tour to visit several institutes and universities. I had the pleasure of talking with you about the Salk Institute. I was impressed by your openness and curiosity to learn from other institutes, and I was wondering how much you would be able to take back to Austria. To me it seems now that if there is an institute that combines the best of the European and the US systems then it must be ISTA. During my interview, I was impressed by this remarkable place and what it has accomplished in its short history. My colleagues in computer science, mathematics, and neuroscience know about the Institute. But since it is a new one, people from other fields ask "What is this place and why are you going there?" When I start telling them more about ISTA, its founding and where it's heading, then everyone understands. In the end, no one questions my decision—even though it means leaving a prestigious institution like the Salk Institute.
Tom: What exactly do you tell them?
Martin: Well, I always start with the high quality of science at ISTA and the remarkable breadth across different fields. I often talk about the scientists who are already here and what they have accomplished. Then I soon find myself talking about the amazing infrastructure and possibility to create new research fields. ISTA's concept of breaking the boundaries of well-established disciplines and encouraging work across them and between groups is so refreshing and forward-thinking. I also mention the xista Science Park, ISTA's commitment to technology transfer, the unique graduate program—which are all so vital. In short, all of ISTA's principals combined, this compelling package, is what attracts me and leaves people speechless.
Tom: And for you personally? Do you look forward coming back to Austria?

↗ 10-year campus anniversary
↗ 50 research groups
↗ Nature Index Normalized ranks ISTA 3rd place worldwide
↗ Opening: xista Science Park

2019

↗ 10 companies at xista Science Park
↗ 100th PhD graduate

2020



↗ Opening: Sunstone Building
↗ ISTA Faculty awarded 50th ERC grant
↗ Vice President for Science Education Gaia Novarino
↗ Vice President for Technology Transfer Bernd Bickel

2021

↗ New Logo and abbreviation "ISTA"
↗ Opening: Michael Gröller Bridge
↗ 25,000,000 Euro — Magdalena Walz bequeaths largest donation in ISTA's history
↗ 1,000th employee
↗ First Master's graduate

2022

Martin: For me personally, it is a dream come true. I suppose, I would do this job even if it was in a different location. But the fact that I was born in Vienna, grew up in Lower Austria, and have all these ties to Austria is the cherry on the top. Coming back obviously means a lot to me and my family. One cannot plan such things in life. I feel very fortunate that it turned out this way.
Tom: No second thoughts on leaving the US, especially California?
Martin: For sure, I very much enjoyed living and working in California. I enjoyed the openness towards new ideas and working alongside people from all corners of the globe. San Diego has grown into a great research environment and is very collaborative. I didn't leave it because I didn't like it there. I left because I was deeply drawn to this opportunity at ISTA. From the scientific side, I expect a similar openness in the work environment that I found over there.
Tom: Do you see many changes from what it was like 25 years ago?
Martin: Yes, Vienna has changed greatly it seems. Maybe my perspective was also different. It is a stunningly beautiful city.
Tom: Since you are the new president, your vision for ISTA counts more than mine. What do you have in mind?
Martin: I will continue to support an environment in which scientists can pursue their research interests free from external influence. This also implies the ability to think outside of the box, to use state-of-the-art facilities, and to enjoy financial security. Research in the 21st century must strive to break down barriers between disciplines, enable international cooperation, and guarantee access to high-tech equipment. I am also aware of the pressing societal challenges of our times and how we, the scientific community, can make meaningful contributions with our unique expertise. I believe the key lies in diverse approaches and people who question traditional knowledge and have new ideas. It takes people who see what everyone sees, but think what no one has thought before.
Tom: Indeed, ISTA has always been quite unique in this respect.
Martin: Do you know Leo Szilard? He was not a poet but a nuclear physicist, and he once said something that I built into my vision. He used the word "magic" to refer to a miracle that has happened. I'm paraphrasing: It is very easy to pinpoint the problems or issues of an organization, yet it is much harder to say what is needed to reach wholeness. When this wholeness exists in an organization, he called it magic. That is what I am looking for: this magic wholeness of researchers and administration, everyone who works here to support our common mission of science, graduate education, outreach to society, and tech transfer. With it, there is no limit to what can be achieved, from breakthroughs to major global impact. Currently ISTA is such a magical place and I want to foster and preserve that.
Tom: I have great confidence in the future of this institute.
Martin: You mentioned earlier that institutes need leadership change after a certain time but not too often as it causes instability. I really appreciate that you made this transition so continuous. It makes it much easier for me to get started. Also, nobody wants an abrupt disruption, something that sends a shock into the system. You have been very thoughtful. You let me decide what I needed from you and did not impose your ideas. Truly, you have been a great resource for me. I feel very supported but not pushed in one or the other direction. You also gave me the space to get to know the Institute and its people.
Tom: As it should be.
Martin: Tom and the team that worked with him deserve enormous gratitude for what they have accomplished at this institute. Thank you!

↗ New ISTA President Martin Hetzer
↗ Opening: Moonstone Building

2023

↗ Opening: VISTA – Science Experience Center (in planning)
↗ Opening: New kindergarten (in planning)

2025

↗ Around 90 research groups
↗ Campus expansion ISTA Platform (in planning)

2027

↗ Around 150 research groups and 2,000 employees

2036

Sharing Knowledge

Training the next generation of scientific leaders is one of ISTA's core missions, and the Institute offers career opportunities on every level. With internships and fully funded doctoral and postdoctoral positions, young scientists can follow their curiosity and grow into their potential.

176
Postdocs

Fully Funded PhD Program

Internships for Under-graduates

Admission by Graduate School

Rotation

PhD Qualifying Exam

PhD Student
5–6 years

Change of Institution

Postdoc
up to
5 years

Young researchers with a doctorate can enhance their careers with a postdoc position at ISTA.

Change of Institution

Early-career scientists seeking a tenure-track position with the freedom and resources to prove themselves can apply for an assistant professorship.

Tenure Evaluation

Advanced researchers interested in a tenured position in an outstanding work environment can apply for a tenured professorship.

Assistant Professor
5–7 years

Tenured Professor

Staff Scientist

Tenured Staff Scientist

Staff scientists provide expertise not available within the research groups.

38
Average Age of all Professors upon Recruitment

Career steps at ISTA

Administrative Support

Professionals in a variety of administrative areas

Scientific and Technical Support

Supporting experts provide research groups with scientific and technical assistance

PhD Students

Enabling the Best Researchers of Tomorrow

Dean Eva Benková congratulates mathematician Katharina Ölsböck on her doctoral degree.

Researchers must fulfill a multitude of roles in order to be successful. At ISTA, students are trained in a cross-disciplinary approach, work with top researchers on cutting-edge science, and engage in a plethora of activities and trainings to broaden their skillsets. All this prepares them for a successful career while expanding the frontiers of human knowledge.

World-class research needs world-class scientists. ISTA's Graduate School provides an extensive and cross-disciplinary education to train the researchers of tomorrow. "We not only want to enable our students to reach scientific excellence", remarks Eva Benková, Dean of the Graduate School, "but also to broaden their perspectives so they can see what is going on outside the lab and become the best scientists they can be."

Fostering cross-disciplinary education

The goal of ISTA's PhD program is to provide the best environment possible for students to become curious and open-minded scientists. They learn to approach problems from many different angles and collaborate with colleagues from a range of fields. Students with a Bachelor's or Master's degree in a relevant field may undertake their doctoral studies at the Institute. In 2021, ISTA introduced the option of earning a Master's degree en route to a PhD. For this, the student must complete additional curricular components and complete a separate project.

In 2022, 64 new students joined the PhD program. At this stage of the program, they belong to a general research area (or "track"), but not to any particular research group. During the first year, they rotate through at least three of ISTA's research groups to get to know the scientists and their work. Each stint takes about two months, during which the students perform research in a laboratory or work on a theoretical project. Maria Trofimova, Head of the Graduate School Office, adds that "the rotations are an excellent opportunity for students to learn to think in multiple disciplines and build up cross-disciplinary connections and knowledge." Alongside their rotations, ISTA students develop their skills and knowledge in courses and trainings in all fields of research present at ISTA. Afterwards, students affiliate with a research group to continue their research. Some students, whose interests and expertise span several research areas, may join two research groups. These co-supervised students benefit from the guidance and resources of both supervisors' groups, in many cases fostering interdisciplinarity (see interviews on page 23).

ISTA's PhD students are fully employed with a competitive salary and pay no tuition fees—an arrangement unusual among comparable institutions. This ensures that the program is accessible to students of all socioeconomic backgrounds.

Some students already get to know the Institute during a research internship on campus. Whether hired by principal investigators throughout the year or as members of the Graduate School's ISTernship program, interns have the chance to gain hands-on experience in cutting-edge research and form connections to ISTA's scientists. It happens regularly that former interns apply successfully to the Institute's PhD program.

Supporting research

A robust support infrastructure is necessary for scientists to perform their research effectively. Students at ISTA can use all the state-of-the-art facilities available on campus—ranging from electron microscopy and nuclear magnetic resonance imaging to the Preclinical Facility, the computing cluster, and a well-stocked library.

ISTA also assists students in organizational matters such as residency, visa issues, or housing on campus. There are many opportunities for scientists to gain additional skills at talks and trainings and to plan their future in academia, industry, or other areas with help from ISTA's career development services. The Grant Office supports all scientists in the crucial task of writing funding applications. "It is important to us to provide students with ample support structures so they can concentrate on their education and research", Trofimova adds. A range of seminars, colloquia, and conferences at the Institute further encourage interactions between scientists working in different fields and with society outside academia.

The xista Tech Transfer team is available to help them to develop commercial applications of their research and organizes events to facilitate contact with industry representatives. Moreover, the Science Education, Communications, and Events teams enable students to engage in diverse science communication efforts—from teaching science at local schools to public presentations at the yearly Open Campus Day. There is also a special program to fund student-driven projects with interdisciplinary character. With personnel costs covered for up to three months and an additional research allowance, young scientists can gain first-hand experience with the entire research project cycle, from grant writing and evaluation to interdisciplinary collaboration.

Alumni

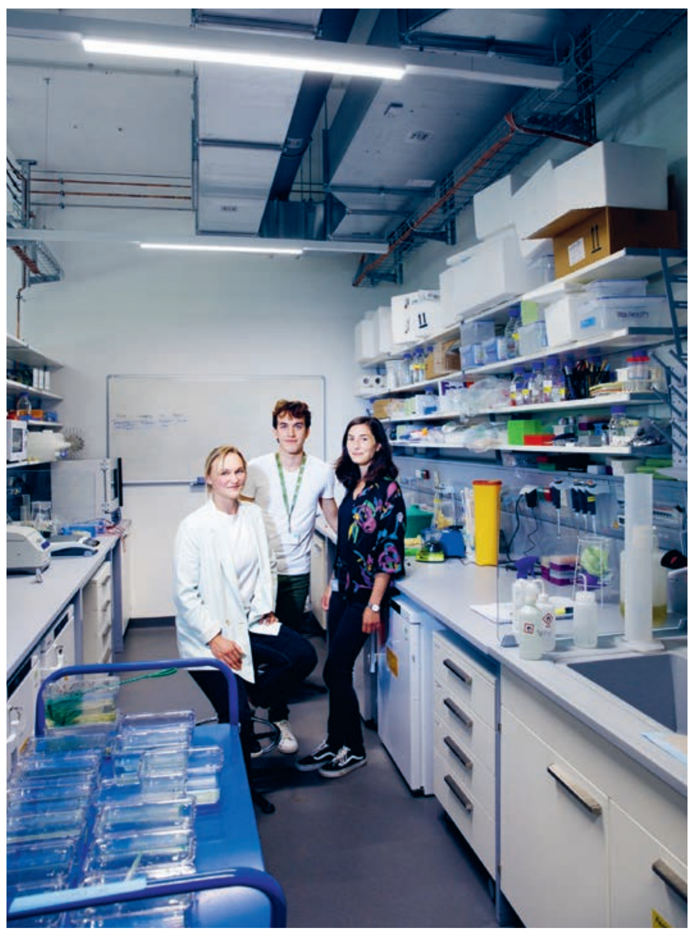
Both the number of research groups and of alumni at ISTA are steadily increasing. In 2022, 23 students finished their studies and joined the Institute's rapidly growing alumni network. With former students distributed all over the world (see pages 32–33), the alumni network offers many opportunities for future collaborations between scientists as well as the chance to stay in touch with ISTA.

2022 was a special year, as ISTA was host to its largest-ever graduation ceremony. Following the easing of measures against the Covid-19 pandemic, graduates from the past three years were finally able to gather and celebrate their achievements in person. Benková concludes, "Our main mission is to help young people become the next generation of excellent scientists. I personally would be very glad if our students look back one day with the feeling that ISTA is their true alma mater."

Becoming Exceptional Researchers

Students may start a PhD already knowing their research question; others may get inspired in their first-year rotations to enter a completely new field. Natalia Ruzickova and Jakub Svoboda are both in their fourth year, exemplifying the inter-disciplinary atmosphere in ISTA's student community.

Hopping into science: Graduate students in the Sweeney group seek to understand motor circuits using the *Xenopus* frog.



Natalia Ruzickova
4th-year PhD student
in the Tkačik group

What brought you to your current area of research?
I studied physics, but I was always interested in understanding living systems. Answering complex questions in biology often requires modeling and sophisticated data analysis, as is the case for my projects. I like merging the methods mathematicians and physicists would use, and applying them to data from biological experiments. There is a lot of unexplored ground between the traditional disciplines, and such a cross-discipline approach feels like the "best of both worlds" for me—merging the methods I like with the topics that interest me.

What is your research about, what motivates you to do it?
I work on the pancreas, and ask: What strategies do pancreatic cells use to keep our blood sugar levels in a healthy range preventing diseases such as diabetes? The pancreas has many small clusters of cells inside it, which release insulin and other hormones that regulate blood sugar levels. Strikingly, cells inside these clusters "talk" to each other and synchronize their activity—as if they marched in unison after blood sugar goes up. We try to understand the purpose of this synchronized activity. For example, is the pancreas able to react faster and more accurately to a rise in blood sugar after eating a piece of chocolate? It turns out that in diabetes, this cell-to-cell "talk" does not work properly. Therefore, understanding the function of synchronous response of pancreatic cells may help us understand the causes of this disease. I also collaborate with an experimental physiology lab in Vienna that employs an ISTA alumnus. Every time I visit them, I learn more about how complex the physiology of the pancreas is. I enjoy the challenge of trying to describe the behavior with the simplest model possible to gain insights. I also like the challenge of communicating with experts from different fields. It is a little like learning a new language and it teaches me to express my thoughts clearly.

Jakub Svoboda
4th-year PhD student
in the Chatterjee group

When did you decide to become a researcher?
Instead of a defining moment, there was a sequence of steps. The first and biggest one was when I learned about math competitions and correspondence seminars in high school. I enjoyed playing with math problems in my mind. The next step was discovering competitive programming. Algorithms are even more fun to think about. The final step was an internship at ISTA. There, I learned the ins and outs of a research job and I loved it.

What are your main scientific interests?
I have two main directions. The first is games on graphs. Many situations that require optimal decisions can be modeled as a network where every node belongs to player A or player B or is random. If there is a token on one of player A's nodes, they can move it to a neighboring node. It works similarly for player B and otherwise the token moves randomly. A tries to reach a special node and B tries to prevent that. The other direction is stochastic evolutionary processes. There, every network node is occupied by an individual of some type. Based on randomized rules, one individual can replace another. Eventually, one type wins. I am interested in how the shape of the network influences the spreading of different types. Both of these directions explore something that is often misunderstood: decisions under uncertainty. These can lead to costly mistakes and I would like to help to better understand them. I also collaborate with a colleague from a cryptography group at ISTA. We are creating algorithms that would make paying with Bitcoin or other cryptocurrencies cheaper. Instead of sending coins back and forth and paying for each transaction, there can be intermediaries that resend your transactions. We designed an algorithm for these intermediaries telling them which transactions to forward and which to reject such that no matter what happens in the future it will be similarly good as an optimum solution.

Science Education & Outreach

Building Public Trust into Science

A basic understanding of science and trust in its processes is vital for modern societies. Fostering an understanding of science as a process and making cutting-edge basic research accessible is a key objective of ISTA's institutional outreach and science education efforts.

With the appointment of Gaia Novarino as Vice President for Science Education in 2021, public outreach at ISTA has received a massive boost. It has gained further momentum with the establishment of the Science Education team as an independent unit and the appointment of Christian Bertsch as Head of Science Education this year. Therefore, the course has been set to broaden and deepen outreach at the Institute. ISTA aspires to become an international reference center for innovative science education with a strong focus on fostering an understanding of the nature of science and cutting-edge research. The approach is to address science as a process and method of thinking, rather than simply talking about science as an accumulation of ready-made facts.

Science education for all

"We at ISTA are now able to strengthen our activity portfolio in different directions", Bertsch says. "By inviting young science enthusiasts to workshops in our new Science Education Lab, we inspire the next generation of scientists and problem-solvers. Using science 'busking' activities to reach out to young people in parks and youth centers, but also on YouTube and TikTok, we foster science literacy and promote science for all. By offering 'Fakebuster Boot Camps' and debate clubs on socio-scientific issues we address science distrust and skepticism."

The Science Education Lab will also be a learning space for ISTA scientists with opportunities to improve their science communication skills. "Learning how to communicate your research so that people outside the specific academic fields will understand will make you a more successful researcher. More and more funding schemes expect you to have additional outreach programs and educational activities can be helpful to secure grants. Communication skills are needed for pitches, convincing investors, or for inspiring teaching", explains Bertsch.

At Open Campus, visitors are toured through laboratories and have the chance to look behind the scenes.

Making science relatable
Instead of just showing scientific results, talking about the entire research process and ensuring a relatable representation of the scientists behind it is necessary to build public trust. A great way to create lasting interest in science is by offering outreach activities along a learning path for all ages. “We always think about how to make a more systemic impact, so that our events are more than just a nice afternoon spent”, says Magdalena Steinrück, an ISTA alumna who is now part of the Science Education team.

From science to school — Science Education Day
Educating science teachers by making science accessible to them is another way to strengthen science education in a more systemic and long-lasting way. In 2022, the highlight was another edition of the Institute’s Science Education Day on March 30, which was attended by a hundred teachers from Vienna, Lower Austria, and further away. The theme this year was “Eine Welt voll Daten” (a world of data). Steinrück recaps, “Our goal is to equip science teachers with different approaches for talking about the nature of science with their students. Data literacy is a rather new aspect of this that we wanted to address in this year’s event.” A keynote by ISTA Professor Christopher Lampert titled “Are data the new oil?” was followed by different workshop options for teachers to choose from. “What makes the event popular with teachers is that it familiarizes them with contemporary science, which they don’t get a lot of in their classical training”, Steinrück says.

“At ISTA, we inspire the next generation of scientists and problem-solvers.”

Christian Bertsch, Head of Science Education

ISTA Lecture Young Lounges
A new initiative by the Science Education team took off in June 2022. The ISTA Lecture Young Lounges precede the ISTA Lectures given by eminent international speakers and science laureates. The Young Lounge offers a small group of interested high school students a chance to interact with speakers in an informal setting. At the three lounges held in 2022, groups of students met with Nobel laureate Venkatesh Ramakrishnan, acclaimed computer scientist Stuart Russel, and Meta Platforms, Inc. Vice President and Turing award holder Yann LeCun. Steinrück hosted some of the Young Lounges and says that some of the best questions to the speakers were asked by the youngsters, “and when the speakers know they are talking to young ones, they give more accessible answers, which makes these interactions particularly authentic and valuable.”

Open Campus Day is always fun for all ages.

At the ISTA Lecture Young Lounges, students meet acclaimed scientists like Nobel laureate Venkatesh Ramakrishnan.

Summer camps
Hundreds of local school students of different ages gather on campus, to participate in the summer camps, which are conducted in cooperation with the University College of Teacher Education in Lower Austria (PH Niederösterreich). They combine signature activities of science education with a playful approach. As part of the camps, participants get to meet scientists, which is a great opportunity to shed science-related stereotypes early on.

Zoom a Scientist
Zoom a Scientist is a series of online meetings between schools and ISTA scientists. Originally started in 2020, the sessions continued throughout 2022, covering topics from quantum spin liquids to sex chromosomes. A central aspect of the sessions is the personal encounter of school students with young scientists and learning about career paths and the daily work in their respective fields.

Open Campus Day
On June 25, the Institute welcomed visitors at the annual Open Campus Day. More than 1,800 people joined the science party, which featured hands-on activities and exhibits for the whole family.

More highlights

- ↗ Ant farm exhibited by the Cremer group at the Natural History Museum in Vienna
- ↗ Cloud Exhibit and panel talk at Vienna Design Week by the Muller group and ISTA Exhibition Curator Mia Meus
- ↗ ISTA at the Long Night of Research
- ↗ ISTA at the Lower Austrian Research Festival

The partnership between ISTA and the NOMIS Foundation fosters cross-disciplinary research. This year, the Fink, Higginbotham, and Katsaros groups were awarded a joint NOMIS project.

Postdoctoral Researchers

Tailor-Made Fellowships at ISTA

Once a PhD is finished, pressure rises to outline a career path, especially since landing a professorial appointment is highly competitive. ISTA provides postdoctoral with the flexibility they require: The NOMIS and IST-BRIDGE fellowships offer tailored skill development and interdisciplinary approaches for any potential next step, be it in academia, the private sector, or elsewhere.

The postdoctoral funding landscape is highly competitive. Often, interdisciplinary researchers find themselves between the target groups of specific calls. ISTA created two fellowship programs to address this: a joint program with the NOMIS Foundation with cross-disciplinary possibilities and the IST-BRIDGE program, which allows fellows to not only bridge scientific disciplines, but also to connect to institutions and even passions outside pure research.

NOMIS — Partnering up to advance the sciences
The partnership between NOMIS and ISTA is now in its third year with ISTA currently hosting seven outstanding fellows. The fellowship is fully funded for two years and allows scientists to pursue a postdoc at the intersection of two or more scientific disciplines. This cross-disciplinarity is one of ISTA's flagship commitments as well as the hallmark of the Zurich-based NOMIS Foundation. At ISTA, fellows have the freedom to perform cutting-edge science with state-of-the-art resources accompanied by multifaceted collaborations between laboratories and scientific services. NOMIS fellow Mandy Bethkenhagen, for instance, joined the Cheng group for computational material sciences, and now investigates chemical reactions on exoplanets. NOMIS fellows can be co-supervised by two different group leaders at ISTA. External secondary supervisors can also be proposed, should the interdisciplinary know-how not be available at ISTA. In this case, the fellows can spend up to three months per year at the external's research facility. Furthermore, teaching at ISTA is encouraged as it is a great way to reflect and distill scientific ideas. Specific training and career development throughout their stay at ISTA allow researchers to excel and lay the foundations for becoming future scientific leaders.

Different Career Paths through NOMIS & BRIDGE

Scientific careers are not set in stone. The NOMIS and BRIDGE fellowships at ISTA facilitate the necessary flexibility. Felix Frey and Yi-Ling Hwong, both post-doctoral researchers at ISTA, explain their research projects and provide insights into what is special about their fellowships.

IST-BRIDGE — Flagship program for ISTA
Since its launch in 2021, IST-BRIDGE fellowships were awarded to postdoctoral researchers in fields ranging from mathematics to life sciences. 21 of them are currently on campus and 4 more are due to join in 2023. One of the fellowship holders is Katharina Lichter, who researches synaptic signaling in the Jonas group. “I’m fascinated about understanding the complex secrets of brain signaling”, says Lichter. “To achieve this goal, I need an interdisciplinary research environment of masterminds from different disciplines, but also an excellent research infrastructure.” She benefits from the Institute’s Scientific Service Units (see pages 56–58) as she requires special microscopic techniques for her work.
The program is fully funded for two years and allows the fellows to work with supervisors and ISTA staff to develop a useful skillset that prepares them for unique career paths. Yet, with the BRIDGE fellowships, it is recognized that exceptional research not only means doing experiments. BRIDGE fellows can choose career tracks from an array of disciplines spanning different departments at ISTA, for example, academic leadership, entrepreneurship, science outreach as well as research and innovation.
Through the BRIDGE academic secondment, scientists can take a deep dive into various fields of different research groups at ISTA or in one of the world-class institutes within the BRIDGE network that ISTA is part of. The network includes the Francis Crick Institute in the UK, the Okinawa Institute of Science and Technology in Japan, the Rockefeller University in the USA, and the Weizmann Institute of Science in Israel.

Felix Frey
NOMIS fellow in the Šarić and the Loose groups

What is your research about?
I’m combining physics and biology to investigate how plasma membranes become deformed during various biological processes with a crucial focus on archaea—a group of single-celled organisms that are neither bacteria nor eukaryotes. Archaea often dwell in extreme conditions of high temperatures, pressures, and highly acidic environments where one would think that life is hard to find. Not much is known about how they survive extreme conditions. But we think that their unique mono-layered plasma membranes—compared to bi-layered membranes seen in bacteria and eukaryotes—have something to do with it.

What stands out in your specific fellowship?
Previously, I did my PhD at Heidelberg University and a postdoc at TU Delft. The NOMIS fellowship is providing me the opportunity to work with two great research groups from different fields and apply methods that I have not used before. The coming together of many disciplines and approaches in my work will help us understand how fundamental cellular processes such as cell division work in different organisms and with different materials. This is really exciting to me. Already in my first few months at ISTA, I have had scientifically inspiring encounters.

Yi-Ling Hwong
IST-BRIDGE fellow in the Muller group

What is your research about?
My research field is climate modeling with a special focus on studying the impact of physical clouds—not IT-structured ones—on climate change. Clouds are rarely randomly scattered across the sky. They form organized patterns and can clump into different groups. This clumping might have a significant impact on our climate. For instance, extreme rain is more intense when clouds are more tightly clumped together. I am trying to understand how the clouds are organizing themselves as climate change takes place.

What stands out in your specific fellowship?
My background is in engineering and particle physics but I have a PhD in science communication and machine learning. The funding allows me to sharpen my skills in fields outside of academia. Personally, that’s very exciting as I’m very interested in climate policy and advocacy. I’m passionate about science and the cross-section between science and society. It would be great if I get a chance to become a scientific advisor or expert in climate policy panels. Therefore, I am planning to do my BRIDGE secondment in a policy institute, to learn how to incorporate scientific knowledge into concrete legislation.

Alumni

A Growing Global Network

When ISTA PhD graduates and postdocs move on to universities and research institutions around the globe, they join the ranks of professors, start leading research groups, found companies, or make their own unique way towards success. After only a dozen years, the global network of ISTA alumni consists of respected scientists, company leaders, and outside-the-box innovators in industrial research and development. ISTA's Alumni Relations team aims to maintain an active connection with and nurture this network of currently more than 550 individuals.

Today, ISTA alumni reside in 39 countries around the globe. Around 18 percent are still employed in Austria. Large groups of former ISTA researchers can also be found in Germany (12 percent), the UK (8), the USA (7), Switzerland (5), and France (4). The majority of ISTA alumni remain employed in academia. More than one third of ISTA alumni in academia have received faculty positions. A quarter of the alumni have found a position as an assistant professor. Five percent are associate professors and three percent are already full professors. Every twelfth one leads their own research group. Around one fifth switched to business and industry.

A protein called Atossa

Among the ISTA alumni is cell biologist Shamsi Emtenani. During her time as a postdoc at ISTA—after earning her PhD at the Institute—the Iranian discovered a new protein that boosts energy production inside immune cells and thus increases their power to enter tissue. Her work in the Siekhaus group was defined by one question: How can immune cells move into new tissues to find and destroy infections that came from the outside of the body? Eventually, by investigating this crucial process, Assistant Professor Daria Siekhaus and Dr. Emtenani ended up answering an even bigger question: What governs the energy needed for cell invasion?

The ISTA researchers discovered a two-fold program that boosts energy production inside immune cells, thereby supplying the power needed for their invasion into tissues. A previously unstudied protein governs this novel pathway. Though they experimented with fruit flies, the researchers' results showed that similar proteins in mammals exhibit the same function. "I looked at this specific gene out of curiosity", Emtenani explains and adds, "The exciting thing is: If you are the first one to discover a gene's function in the fruit fly field, you get the chance to name its protein!"

Thus, she named the protein "Atossa", after a Persian queen. Shamsi Emtenani continues her postdoctoral research at the Institute of Molecular Biotechnology (IMBA) of the Austrian Academy of Sciences.

Turning top-tier research into successful business

One ISTA alumnus who has taken a successful entrepreneurial path is Harold de Vladar. He was a postdoctoral researcher in the Barton group, the first ISTA research group, which still exists today. After his time at ISTA and subsequent scientific positions, he founded the company Ribbon Biolabs. Based on innovative techniques from research, the company offers synthetic DNA strands needed in biotechnological and pharmaceutical research.

The story of entrepreneur Harold de Vladar is not only a successful alumni story, but also an example of successful tech transfer at ISTA since the in-house seed fund, xista Science Ventures, supported the start-up.

ISTA Alumni Award

The ISTA Alumni Award was launched in 2022. It sheds light on outstanding alumni and their achievements. The ISTA Alumni Award values the contribution that ISTA alumni make to the enrichment and advancement of their scientific field in academia, their profession in industry or public institutions, or to their community and society as a whole.

The first award winner is mathematician Anton Mellit, who has become a tenured associate professor in the Mathematics Department at the University of Vienna after his postdoc in the Hausel group at ISTA. During his time at ISTA, the Ukrainian scientist worked closely with Tamás Hausel and published influential papers about knot theory, algebraic combinatorics, algebraic geometry, and number theory. His results received praise after being published in the *Annals of Mathematics*, *Inventiones Mathematicae*, and the *Duke Mathematical Journal*.

Shamsi Emtenani: Former Siekhaus group PhD student and postdoc, IMBA

Harald de Vladar: Former Barton group postdoc and founder, Ribbon Biolabs

Anton Mellit: Former Hausel group postdoc and associate professor, University of Vienna

Unbounded Curiosity

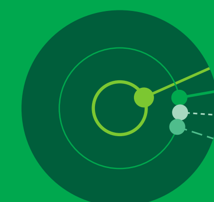
On the ISTA campus, theoretical and experimental groups have absolute freedom in their research, and collaborations between groups and across disciplines are encouraged. Even the selection of 2022 research highlights displays the breadth of scientific advances achieved at ISTA.

4,199
Total Publications since 2008

402
Publications in 2022

36
Cross-group Publications in 2022

322
Cross-Group Publications since 2008



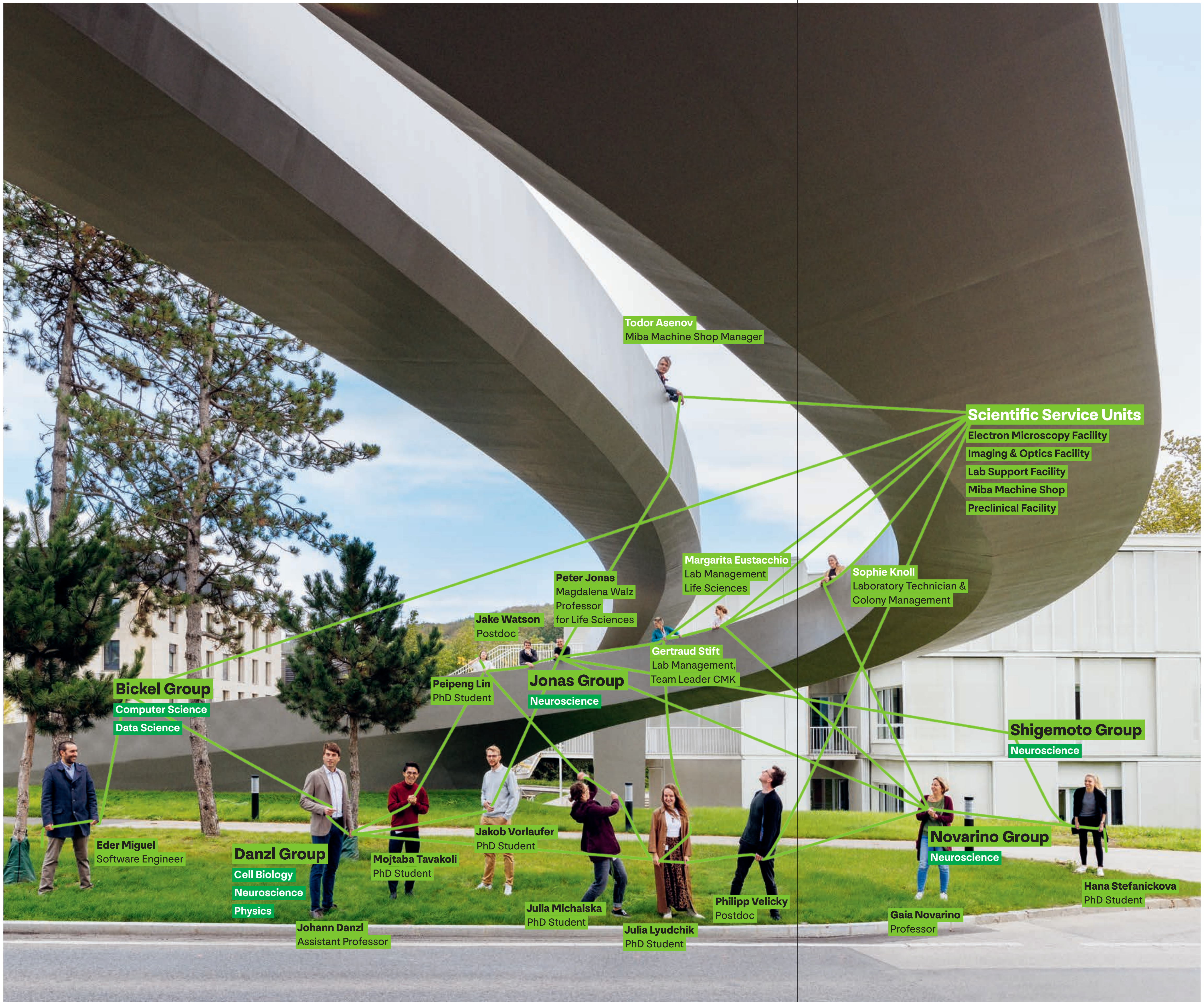
Featured research highlights and involved professors (pages 38, 44, 48)
Research highlights and involved professors (pages 40 ff.)
Involved Scientific Service Units (SSUs)
External partners
Faculty members at ISTA

Science & Research

Building Bridges between Disciplines

Today's most pressing challenges often lie at the intersection of traditional scientific fields. To gain knowledge, understand their inherent questions, and find answers requires successful cooperation of the brightest minds from various backgrounds. Since every field has its distinct language and formalism, how can this work out?

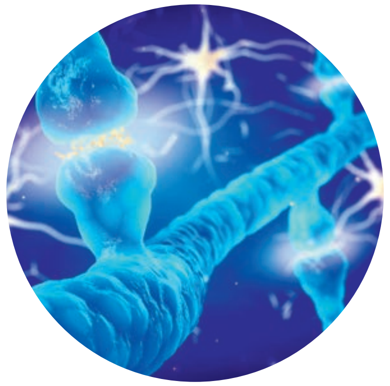
At ISTA, PhD students rotate through disciplines in their first year; postdocs may be hired through one of the many interdisciplinary fellowships; faculty members and external experts give institute-wide talks and lectures. Even small details on campus nudge scientists into communicating with each other, and putting their heads together on issues much bigger than a single discipline. ISTA actively fosters such an atmosphere of interaction, which enables cutting-edge multi- and cross-disciplinary research. **Multidisciplinarity** means hiring the best researchers in their respective fields such that a faculty of 67 professors represents all major scientific disciplines. While excellent research within a discipline is equally welcome, ISTA encourages **cross-disciplinarity**, where scientists from different scientific backgrounds collaborate, each with their own perspective on the research topic. In 2022, numerous projects exemplified this spirit of collaboration, a few of which are portrayed in the subsequent pages.



Precise Snapshots of the Brain

"The quality of scientific interactions and the professional scientific support at ISTA is incredibly enriching", says Assistant Professor Johann Danzl. Scientists from different fields together with five different Scientific Service Units contributed to this project. The physicist Danzl collaborated with computer scientist Bernd Bickel and scientists at Harvard University on the visual computing aspects. Four neuroscience groups offered their respective expertise: Peter Jonas in functional analysis of brain tissue. Artificial miniature brain-like organs used in the analysis came from Gaia Novarino, and human tissue from Sandra Siegert's lab and collaborators in Vienna. The group of Ryuichi Shigemoto and collaborators from Edinburgh and Berlin concluded the top-notch line-up, bringing further techniques for tissue labeling to the project.

Cell Biology
Computer Science
Data Science
Neuroscience
Physics



Synapses in the brain connect neurons and fire chemoelectric signals.

Interdisciplinary project; see previous page

Bickel, Danzl, Jonas, Novarino, Siegert and Shigemoto Groups
Precise Snapshots of the Brain

A highly collaborative research project opens up new vantage points on the architecture of brain tissue, fusing optical microscopy, deep learning, and biological analysis.

Human brains accommodate around 86 billion neurons, wired by synaptic connections into an extremely complex information-processing network forming the basis of all brain functions. Synapses themselves often measure just a few hundred nanometers to a few micrometers in size. Decoding these tiny structures would help to understand the brain's foundations.

Therefore, Assistant Professor Johann Danzl and his research group developed highly precise light microscopy techniques that provide information on brain tissue that has not been accessible to researchers up to now.

Working across disciplines, the scientists now present two technologies for in-depth analysis of brain tissue. "LIONESS" is an integrated optical imaging and machine learning technology that uniquely enables researchers to reconstruct the 3D structure of all the cells in living brain tissue at nanoscale resolution and follow how it changes over time. It is based on stimulated emission depletion (STED) super-resolution microscopy and uses deep learning to make 3D imaging compatible with living tissue and for reconstruction. The related "CATS" technology visualizes the architecture of brain tissue across scales of spatial organization, from the organ level down to the level of synaptic connections.

Data Science
Evolution & Ecology
Mathematics

A snapdragon in Catalonia. Nick Barton and his team have examined thousands of these plants for their research.

Barton Group
How Flowers Protect Themselves from Bad Genes

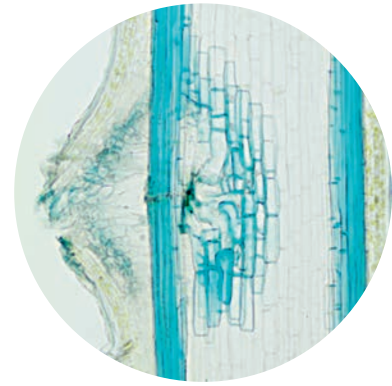
Snapdragons (*Antirrhinum*) are flowering plants from the western Mediterranean. A research team at ISTA has been making an intense study of an *Antirrhinum* population in the Pyrenees, to determine their family relationships.

Like humans, each individual carries two copies of each gene, one from each of its parents. If one is defective, this typically does little harm. However, an inbred individual can receive a defective copy of the same gene from both father and mother, which can have severe consequences for its health.

Professor Nick Barton's group at ISTA has been making a long-term study of a population of a few thousand snapdragons, aiming to understand what shapes diversity, despite inbreeding. Over more than a decade, 20,000 individual plants were characterized genetically, allowing the researchers to estimate parent-child relationships between the plants across the years. Surprisingly, the plants from a given year hardly ever had parents from the previous year. Most likely, seeds that fall to the ground stay dormant for several years before they germinate to produce descendants. This reduces inbreeding and maintains diversity because relatives are separated by time as well as space.

These snapdragons have evolved many such mechanisms to reduce inbreeding. The Barton group is also studying a complex set of genes that work together to prevent pollen from the same plant, or a close relative, from successful fertilization.

Cell Biology



Vascular regeneration at six days after wounding in *Arabidopsis thaliana*.

Friml Group
Solving a Plant-Signaling Mystery Half a Century Old

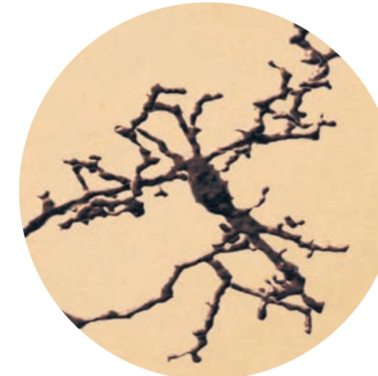
Scientists investigate the mechanisms governing development in plants by addressing the long-debated role of ABP1 in auxin perception.

Auxin is a plant hormone essential for regulating growth and development. For example, it is responsible for leaves turning towards the sun. Inside the cell nucleus, auxin has well-characterized roles in transcriptional reprogramming, in particular switching specific genes on and off. However, certain mechanisms mediating fast effects in these plants are still not understood. In particular, the question of whether the protein "ABP1", discovered fifty years ago, acts as an auxin receptor for rapid effects remained unclear.

In a joint effort, Jiří Friml's research group at ISTA and their collaborators critically evaluated this mystery. Their 2022 publication in *Nature* confirms that auxin binds to ABP1 at the cell surface and shows that this binding is crucial for its function.

Using the white blossoming mouse-ear cress (*Arabidopsis thaliana*) as a model plant, the scientists show that the protein binds to auxin with the help of a partner called "TMK1". This ABP1-TMK1 complex is found to be necessary for some auxin-triggered rapid cellular as well as developmental processes. The study further shows that genetically modified plants with an ABP1 or TMK1 disruption could not regenerate after wounding. Importantly, an engineered ABP1, which could not bind auxin, was unable to mediate these processes.

Cell Biology
Data Science
Mathematics
Neuroscience



The Siegert group built a morphological atlas of over 40,000 microglia with a topological data analysis approach in order to decipher microglial morphology in different contexts.

Siegert Group
Revealing the Hidden Meaning of Microglia Shape

To understand the brain's function and adaptation in disorders, neuroscientists turn to microglia cells. In 2022, scientists from the Siegert group have developed MorphOMICs: a pioneering data-driven method that unfolds a map of how brain region, sex, and disease progression influence microglia—all by looking at their shape.

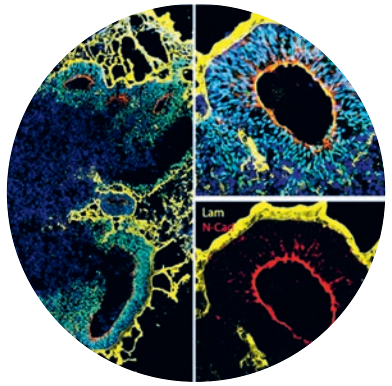
Microglia cells are the first to respond to changes in the brain. Therefore, neuroscientists have actively sought methods for detecting their response early on, before the onset of neurological symptoms. Researchers knew that a microglia's shape encodes key information about its function. However, they only distinguished two extreme states—surveillant and activated—rather than the wide spectrum of intermediate ones because of difficulties resolving the morphological differences.

Then, a talk by mathematician Kathryn Hess at ISTA inspired the Siegert group to look at the cells using topology, a way of analyzing the properties of geometric objects. The cells' intricate tree-like structure, examined from a topological point of view, reveals previously hidden information.

"We were shocked at how well this worked—seeing how microglia morphologies unfold for each brain region and sex, and how they change during disease", says Assistant Professor Sandra Siegert.

With this new approach, the team compiled an atlas of microglia morphologies: MorphOMICs. They have already used their new tool to study differences in microglia response to Alzheimer's in male and female mice.

Neuroscience



Using specific protein markers, it is possible to observe structural details of brain organoids (yellow and red) as well as all the organoid cells in blue and green.

Novarino Group
Miniature Brain Models Help Understand Autism

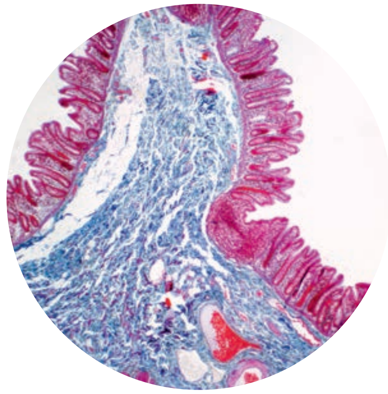
Neuroscientists at ISTA used miniature brains to understand how a mutated gene affects brain development.

Autism spectrum disorders (ASDs) are linked to a large number of genes. For example, mutations of the CHD8 gene are causing symptoms like intellectual disabilities and macrocephaly—an unusually large brain. To help patients with CHD8 mutations, a very accurate model is needed that will give scientists a deep look into brain development at an early stage.

Therefore, Professor Gaia Novarino and a group of international collaborators turned to organoids—simplified miniature versions of organs that are made from stem cells. With the right conditions and the proper input, the Novarino group was able to mimic developmental processes to create basic versions of brain tissue the size of lentils. By reproducing genetic and clinical features from ASD patients in these brain organoids, the scientists hope to get a better view of the basics of brain development.

The scientists generated brain organoids with and without mutations of the CHD8 gene. Similar to patients with this gene defect, the mutant organoids were showing signs of brain overgrowth. Furthermore, the production of inhibitory neurons—a special group of neurons—was started earlier than in the control group and a larger number of proliferating cells, developing into this kind of neurons, was observed.

Cell Biology
Data Science
Physics



Microscopy cross section of villi and intestinal epithelium.

Hannezo Group
New Stem Cell Mechanism in Your Gut

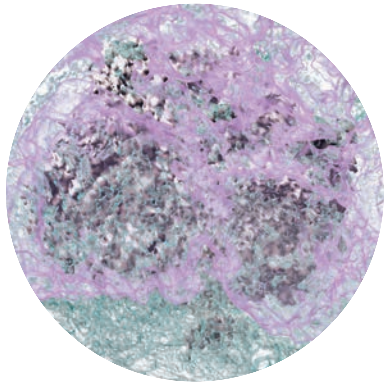
With their implications for possible medical treatments, stem cells are a hot topic in science. In 2022, researchers published a new mechanism that regulates stem cells in the intestines of mice.

In the gut, the epithelium coats the insides of the small and large intestines. It completely renews itself every couple of days using stem cells—a special type of cells that can differentiate into various other cells. These stem cells are constantly dividing at the bottoms of tiny pockets in the tissue called intestinal crypts. Some of these daughter cells are pushed outwards to differentiate into cell types with intestinal functions and others remain there as stem cells. However, scientists still do not know how exactly they make this decision.

Researchers from the Hannezo group and the Netherlands Cancer Institute found a new mechanism that regulates stem cells in the crypts that could change our understanding of what a stem cell is. The research suggests the location of stem cells to be the main driver of their decision-making. Cells in unfavorable positions, which would be pushed out then differentiate, can actively reposition back to the crypt so they can again act as stem cells and replenish the epithelium.

The researchers' background in physics helped them to create a mathematical model of the intestinal epithelium layer that included the motion of the cells going away from and back towards the crypt. Using this model, they can predict accurate numbers of working stem cells in intestines.

Cell Biology
Data Science
Neuroscience
Physics



Cross section through a swollen lymph node.

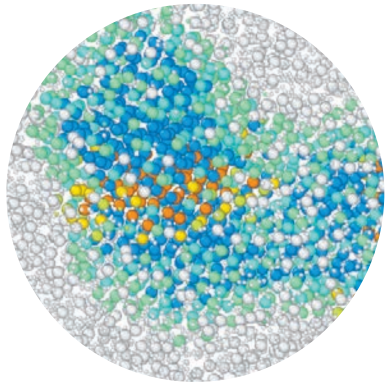
Hannezo, Heisenberg, Hippenmeyer, and Sixt Groups
The Biomechanics of Swelling Lymph Nodes

Checking for swollen lymph nodes is a part of every visit to the doctor. But what does the doctor actually feel? ISTA scientists have now studied the intricate biomechanics of swelling lymph nodes.

Anyone who has ever had an inflammation knows about lymph nodes, which number several hundred in a human body. They initiate the adaptive part of the immune system and start a response with antibodies and cells called lymphocytes. These cells expand, causing the organ to swell. Scientists at ISTA studied how lymph nodes can increase over tenfold in size within a few days but at the same time maintain their structural organization.

"During the last decades, researchers found that not only the lymphocytes but also the structural parts of the nodes play an important role in the immune system. We studied its swelling and found a complex and multi-tiered process", explains Professor Michael Sixt, one of the scientists involved. When the node swells, its cellular skeleton stretches to accommodate short-term changes. If the swelling continues, mechanical feedback triggers these cells to grow and adapt their connections. This happens up to a point, when the stretching causes a remodeling and strengthening of the node's mantle stopping its growth. Once the swelling recedes, the node can shrink down again. Sixt adds, "Our body is controlled by intricate feedback loops. These can depend on chemical signals from cells but also mechanical forces."

Astronomy
Chemistry
Data Science
Physics



Diamond formation from hydrocarbon.

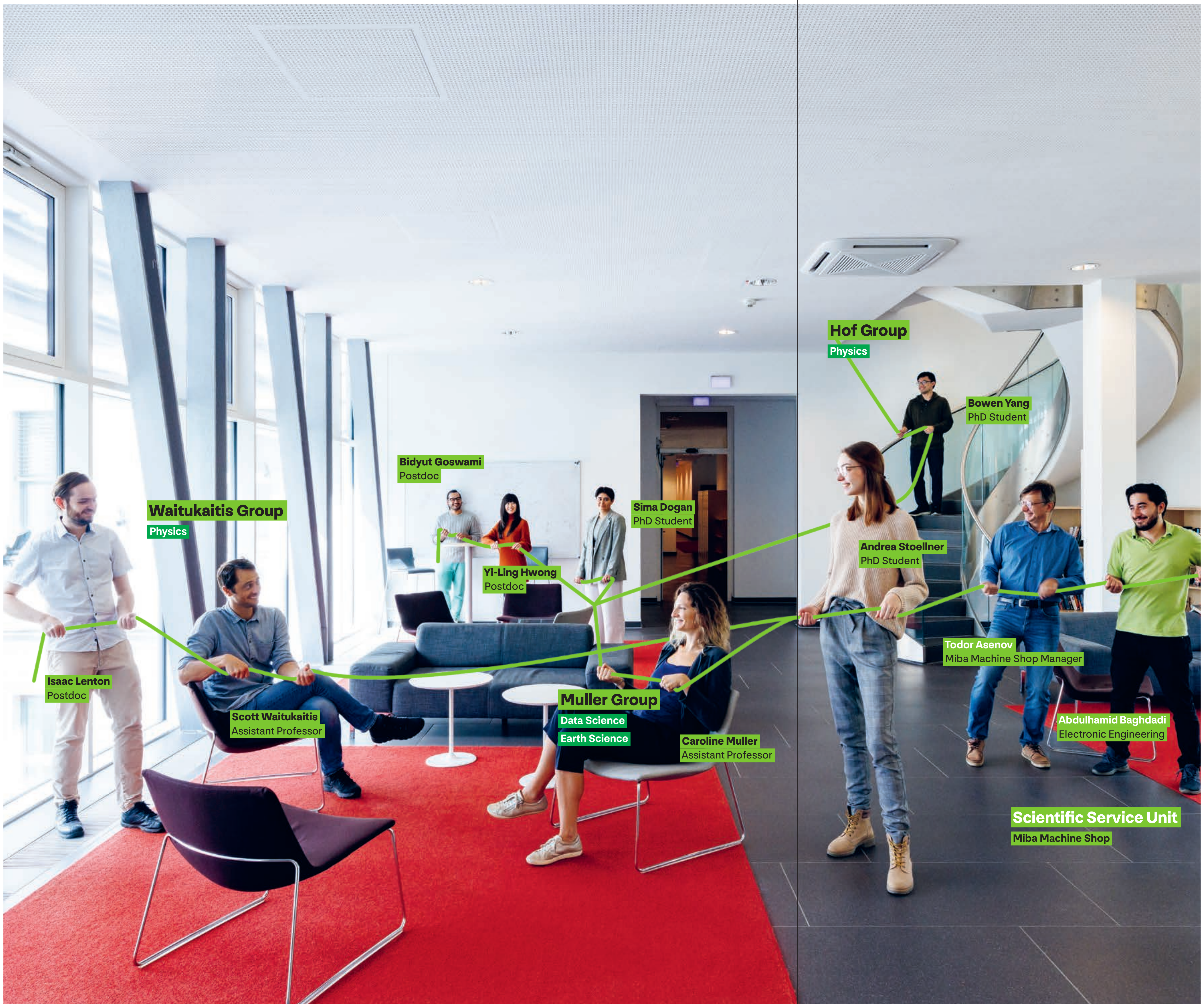
Cheng Group
Diamonds Raining from the Sky

Machine learning applied to quantum mechanics can help scientists to peer into the depths of strange planets.

Quantum mechanics is one of the most successful scientific models of reality. In principle, its equations could predict the properties of almost any material, such as how it builds up structures or transports heat and electricity. However, on a scale any larger than a few hundred atoms at a time, these calculations are far too complex to solve for even the largest supercomputers. This is where machine learning comes in.

ISTA Assistant Professor Bingqing Cheng and her colleagues develop machine learning algorithms to simulate materials based on the laws of quantum mechanics on much larger scales than otherwise possible. They train the algorithms on existing and well-understood systems and then apply them to previously unexplorable materials and environments. This way, they can support the development of new materials and let us peer into regions of space that would never be accessible otherwise.

In their recent work, they simulated the inside of giant gas planets like Neptune. There, the pressure is millions of times greater than on Earth and usually, gaseous elements like hydrogen turn into metal. They found that a mixture of carbon and hydrogen at around 3,000 degrees Celsius even forms diamond structures. Cheng reflects, "While we may never be able to see the inside of Neptune, our calculations can help reveal whether there are diamonds raining from the sky."



Shooting Lasers at Cloud Particles

Andrea Stoellner is co-affiliated with climate scientist Caroline Muller and physicist Scott Waitukaitis. "Caroline's input and expertise help me a lot, as I'm very interested in geo- and environmental sciences, especially in the atmosphere", explains Stoellner. "With Scott, I can perform hands-on laboratory work, as he and postdoctoral researcher Isaac Lenton already had an amazing project about the charging of aerosol particles that could be linked to lightning. Isaac's guidance impacts me enormously. He teaches me the essentials of experimental work." The Miba Machine Shop, a Scientific Service Unit at ISTA, provides both scientists with the required custom-made setups for their experiments. "Doing my PhD at ISTA gives me a great opportunity to combine both the topic and the method of research, which I really enjoy", Stoellner concludes.

Earth Science
Physics

The experimental chamber in which the aerosol particle is held.

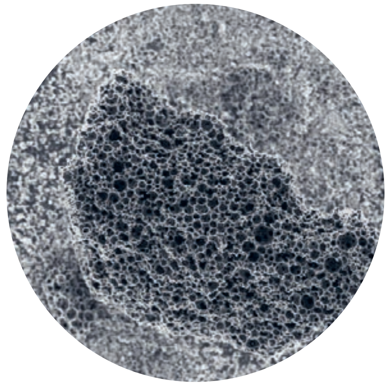
Interdisciplinary project; see previous page

Muller and Waitukaitis Groups **Shooting Lasers at Cloud Particles**

The interactive working atmosphere at ISTA provide a fruitful foundation for excellent young scientists. Andrea Stoellner's PhD project gathers the expertise of various fields around the campus to get a better understanding of the microphysics of clouds and the electricity in the atmosphere.

Small airborne particles are all around us. They vary in size and state of matter. Some of them are visible and present every spring—just think of pollen. Some of them you do not even notice—dust or small water droplets. A shared characteristic is, that they are electrically charged, which influences their behavior and transport in the atmosphere. Whenever enough charge builds up it can lead to lightning in thunderstorms or dangerous dust explosions during industrial processing.
Still, it remains unknown why and how these aerosol particles are charged in the first place. Andrea Stoellner, who finished her first-year rotations and started as an affiliated PhD student is eager to find an answer to this question.
In her research, she is studying one of the possible charging mechanisms by catching a single aerosol particle with laser light and changing the environment around it. Her focus lies on applying an electric field on the particle and subsequently measuring its motion and manipulating its charge. Using this technical approach, she can detect the particles evolving charge very accurately or, in physical terms, with "single elementary-charge precision".

Chemistry
Physics



Ceramic coated highly porous carbon foams that are used as battery electrodes.

Freunberger Group **Developing the Battery of the Future**

The world needs new ways to store electric power. While promising technologies exist, only science can provide answers to open questions.

Every mobile electronic device from phones to electric cars has a battery inside it. Nowadays, batteries have become not only ubiquitous but also essential for the transition to sustainable electric energy usage. However, considerable challenges remain.
Modern batteries are mainly based on lithium and other—even scarcer—rare earth elements. Producing and recycling them requires enormous amounts of energy and causes environmental, economic, and political problems. Therefore, scientists like Assistant Professor Stefan Freunberger and his team at ISTA are working on alternatives.
They develop batteries that use more commonly available elements like oxygen, sulfur, carbon, and nitrogen. "We create new materials and study how electric charge moves through them, how they behave in chemical reactions, and how they could store energy", Freunberger explains. To this end, the scientists make use of the state-of-the-art Scientific Service Units (see pages 56–58) at ISTA ranging from electron microscopy to nanometer-scale fabrication. Recently, they worked on making promising lithium-sulfur batteries more effective and on understanding what happens in the chemical reactions inside them. Freunberger adds, "While basic scientific curiosity is still a major drive for me, I also hope to contribute to new technologies to enable a more sustainable society."

Physics

The snake-like curved structure in the upper half is the sandwich made from an aluminum superconductor and an indium-arsenic semiconductor.

Higginbotham and Serbyn Groups **Super-Semi Sandwiches for Quantum Computing**

In the international race to identify the best platform for controlling and processing quantum information in quantum computers, superconductor-semiconductor "sandwiches" could be key. In order to use them, we have to understand the physics behind them. Now, ISTA researchers and their NYU collaborators have found a new technique to probe these hybrid structures and investigate semiconductor-superconductor interactions.

Semiconductors are the foundation of modern technology, while superconductors could become the basis for future technologies, including quantum computers. It was thought that combining the two types of conductors in carefully crafted sandwich layers would lead to new quantum effects, but convincing observations remained elusive until recently.
With theory support from the Serbyn group as well as help from external collaborators, the Higginbotham group at ISTA created a microscopic aluminum (superconductor) and indium-arsenic (semiconductor) sandwich. New quantum states arise at the interface between the two materials, but in the past, the aluminum layer prevented direct probing. "Sending a current that alternated billions of times a second through the vicinity of the sandwich caused the superconductor's veil to become partially transparent, allowing us to get feedback about the properties of the semiconductor", explains Jorden Senior, a postdoc in the Higginbotham group.

Physics

Printed circuit board for mounting a nanowire sample.

Katsaros Group **A Treasure Hunt for Elusive Particles**

Majoranas are theoretical particles that have not yet been unambiguously verified in experiments. Scientists reported the discovery of a Majorana imposter and propose novel methods to distinguish them from the elusive real ones.

Researchers are feverishly searching for something that could enable quantum computing and thus change our digital world. "Majoranas" are particles that—so far—have only been studied theoretically. However, they are predicted to exhibit exotic properties, enticing physicists around the world to try to find them. In a joint effort between ISTA, the Materials Science Institute in Madrid and the Catalan Institute of Nanoscience and Nanotechnology, scientists revealed the existence of a fraudulent Majorana particle that turned out to be a different novel particle.
Two well-established techniques were applied simultaneously to the same device. By using Coulomb spectroscopy, the researchers found states that are highly suggestive of Majoranas at first glance. However, these states were not present when viewed from a different perspective afforded by tunneling spectroscopy.
The findings prove that convincing Majorana impostors are everywhere and they can deceive measurement strategies when used individually. In the future search for these particles, the novel approach could drastically reduce interpretation ambiguities. Katsaros thinks that "this is a much-needed step towards finally trapping these elusive particles."

Digital Yarn for Real Socks

Georg Sperl is a former PhD student in Professor Chris Wojtan's research group at ISTA. Their publication is a collaboration with the Rey Juan Carlos University in Spain. The annual SIGGRAPH conference, an exhibition on visual computing, where industry leaders are scouting to improve their production lines, allowed the research team to present their efficient and accurate visualization algorithms. It resulted in a partnership with the Spanish company SEDDI and the US firm Under Armour. "Our external partners, especially Miguel Otaduy, professor at the Rey Juan Carlos University and co-founder of SEDDI had a great impact on our project", explains Wojtan. "He offered Georg an internship and guided him through the challenges of working at a company that combines both computer simulations and real-world experiments."

Computer Science
Data Science

Computer simulation of fabrics on the level of single yarns.

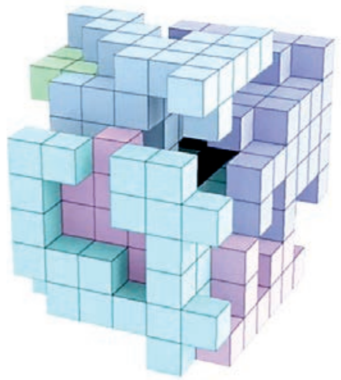
Interdisciplinary project; see previous page

Wojtan Group
Digital Yarn for Real Socks

The Wojtan group's visual computing of knitted yarn captures the complexity of garments. Now, they applied their knowledge to a real-world setting that will benefit the textile industry in realizing new fabrics.

There is a lot of progress in computer science, as algorithms are developed to solve real world problems. Computer scientists like Georg Sperl and Professor Chris Wojtan try to do exactly that. Imagine a textile company wanting to add a new fabric to its portfolio, not knowing how it twists, moves, and stretches. The knitting pattern changes the behavior of the cloth in a complex way. Now, the firm could provide data of different knitting patterns produced from the same yarn. With Sperl's novel method, they can calculate a yarn model, which not only captures the dynamics of the samples but also numerous other patterns with that yarn. Instead of producing all possibilities and checking them, they could simulate the properties in advance. Such virtual examination would save resources. Sperl applied efficient and accurate visualization algorithms, based on real data from the collaboration with the textile industry. His simulation uses a yarn-based approach, where he considers each yarn and its physics. This offers higher control and also captures the complexity. So far, nobody has ever applied this type of yarn-based simulation to real industrial data, but the project revealed how promising this avenue truly is.

Computer Science
Data Science



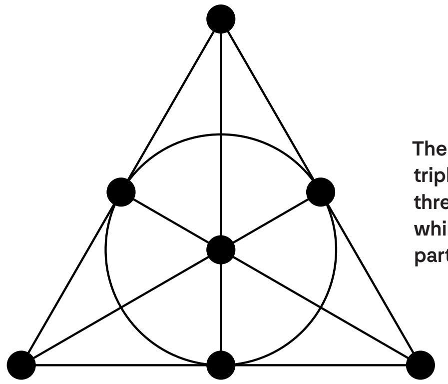
In a virtual environment, the computer scientists modelled the high-level interlocking puzzles, which later were 3D-printed for user trial.

Bickel Group
Unlocking Interlocking Riddles

Professor Bernd Bickel and an international team of researchers released a toolbox to design high-level interlocking puzzles on demand. Their study was honored with the Technical Paper Award at the prestigious SIGGRAPH conference.

High-level interlocking puzzles are geometric games. Their pieces are held together by their geometric arrangement, which also prevents the player from taking them apart. The objects require multiple moves to become disassembled—a very challenging task. Even more challenging, however, is the design of such puzzles.
A collaborative work of ISTA, the Singapore University of Technology and Design, the ETH Zurich, and the École polytechnique fédérale de Lausanne (EPFL) in Switzerland presents a computational approach to designing these interlocking riddles.
The computer program can model any shape as a 3D grid equally partitioned into small unit volumes called "voxels". The algorithm guarantees that all puzzle pieces are of the same size and all voxels forming a piece of the puzzle are connected, thus ensuring the stability of each piece. Additionally, it prohibits designs where you can remove a piece with the first move.
The project does not only work in theory. Users already tested the difficulty of 3D-printed samples designed with the algorithm. The puzzles further demonstrate the possibilities of fabrication of 3D-printed objects and their growing use in technical applications such as robotic assembly or even architecture.

Computer Science
Mathematics



The Fano plane is a Steiner triple system. Each point forms three triples, indicated by lines, while every pair of points is part of exactly one triple.

Kwan Group
Decades-Old Erdős Conjecture Cracked

Many mathematical conjectures can be stated simply, but (dis)proving them is another matter: In 1973, Paul Erdős made a conjecture about the existence of high-girth Steiner triple systems. Now, nearly fifty years later, ISTA Assistant Professor Matthew Kwan and his colleagues at Harvard and MIT have found an answer.

A Steiner triple system is a set of triples over n points, where each pair of points only appears in one triple. Steiner triple systems first arose in the design of scientific experiments—the combinatorics behind them allows scientists to perform the fewest number of trials. Now, these systems have been generalized and are relevant to computer programming and coding theory.
The other part of the conjecture is a property known as "girth". If a Steiner triple system has many triples over a small number of points, it has low girth. If the triples have no such configurations, the system possesses high girth. Erdős conjectured that there were Steiner triple systems of arbitrarily high girth. Little progress was made on this and many other fundamental questions in design theory until 2014, when several probabilistic results revolutionized the field. That turned out to be the key for Kwan and his collaborators. "In order to prove the existence of Steiner triple systems of arbitrarily high girth, we had to avoid algebra and bring in probabilistic methods", explains Kwan.
The new proof comprises a wide array of techniques at the frontier of extremal and probabilistic combinatorics.

Independent by Design

Top-notch research needs state-of-the-art facilities. ISTA provides its scientists with an ideal environment, whether they need high-tech equipment, access to scientific knowledge, or competitive computing power.

9 Scientific Service Units

- ↗ Electron Microscopy Facility
- ↗ Imaging & Optics Facility
- ↗ Lab Support Facility
- ↗ Library
- ↗ Miba Machine Shop
- ↗ Nanofabrication Facility
- ↗ Nuclear Magnetic Resonance Facility
- ↗ Preclinical Facility
- ↗ Scientific Computing

8½ Digit Digital Multimeter

If a ruler had the precision of the Miba Machine Shop's 8 ½ digit digital multimeter, it could measure the distance from Vienna to Hawaii to within 5 cm accuracy.

9.5×10^6 m³ air

The amount of air exchanged in the Nanofabrication Facility since 2017. This is equivalent to the air breathed by almost 1 billion people in a single day.

33 Advanced Microscope Setups

Scientists can dive into worlds invisible to the human eye with the wide range of microscopes available in the Imaging & Optics Facility.

The ISTA high-performance computing cluster grows with the campus community: the number of cores and threads has tripled since 2019.

7,000+ Cores

Article Downloads in Library

371,367

Supporters

Donations for Eternity

100 Million in 5 Years

In June of 2022, ISTA embarked on an ambitious capital campaign, "Be a Giant".

The long-term financial health of the Institute relies on four different sources of funding: public funding, peer-reviewed third-party research grants, technology licensing, and donations. 2022 was an exceptional year for the latter: two significant donations totaling 30 million Euro have kick-started the Institute's—and Austria's—first capital campaign.

ISTA seeks to be a pioneer and to bring the best practices worldwide back to Austria: This year, ISTA broke new ground in research funding, becoming the first research institute in Austria to embark on a capital campaign. Over the next five years, ISTA aims to raise 100 million Euro for an endowment that will serve to secure and support independent, world-class research and education in the long term.
Capital campaigns with ambitious goals are a common and traditional means of renowned research universities such as Stanford University, ETH Zurich, the Weizmann Institute of Science, and many more. In these campaigns, funds are raised to finance an endowment that invests capital for the very long term in order to generate proceeds that co-finance the institution in perpetuity.

A legacy for the life sciences

ISTA's capital campaign was initiated by an extremely generous—and entirely unexpected—donation: When the Lower Austrian entrepreneur Magdalena Walz passed away in 2021, she left 25 million Euro to the Institute in her will. Founding President Thomas A. Henzinger was very moved: "The fact that someone bequeathed us their entire fortune, worth 25 million Euro, is an extremely strong statement. In her case especially, the value of the donation far exceeds the actual amount because it expresses her firm belief in ISTA's model of excellence and independence."
Walz's donation is the largest in the history of the Institute, and it has been used in part to create the Institute's first named professorship, the Magdalena Walz Professor for Life Sciences. Peter Jonas, one of Europe's leading neuroscientists, is the first to hold the professorship. Following the endowment model, when Jonas retires, the Magdalena Walz professorship will transfer to another professor in the life sciences, thus preserving the donor's legacy forever. "That's the beauty of it", remarks Henzinger, "with her donation she has created something for eternity."

Neuroscientist Peter Jonas is one of ISTA's first professors, and the first to hold an endowed professorship.

VERBUND Professor for Energy Science Maria Ibáñez develops the basis for highly efficient low-cost thermoelectric materials.

Enabling the technologies of tomorrow

Verbund AG, Austria's largest electricity provider, set a further milestone with its 5 million Euro donation. The company, which generates 90 percent of its electricity from hydropower, is dedicated to transforming the European energy industry towards a renewable system. Michael Strugl, CEO, explains their motivation, "Verbund is excited about this long-standing cooperation with ISTA, an outstanding domestic lighthouse project in research. Foundations for the technologies of tomorrow enabling reliable and sustainable future development are being developed here. Moreover, the donation not only supports ISTA, but also domestic business and research." As with the Walz donation, a named professorship was created in recognition of this generous gift. Maria Ibáñez, a materials scientist at ISTA, is the first VERBUND Professor for Energy Science.

> "That's the beauty of it—with her donation she has created something for eternity."
>
> Thomas A. Henzinger, President 2009–2022

ISTA Donors Club

Platinum Club
Invicta Foundation
Magdalena Walz
Verbund AG

Gold Club
Karl Wlaschek Privatstiftung
Michael Gröller Foundation
Mondi AG
OMV AG
Raiffeisen Group
voestalpine AG

Silver Club
Berndorf AG
DI Klaus Pöttinger
EMACS Privatstiftung
Martin Gerhardus
Miba AG
Oberbank AG
Prinzhorn Holding GmbH
Schoeller Bleckmann AG
Steven Heinz
W. Hamburger GmbH

Donor Club
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Berndorf Stiftung
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Florian Würth
Gebrüder Weiss GmbH
Kapsch AG
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MEGA Bildungsstiftung
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Therese Niss
Ursula Plassnik
Rudolf Scholten
Veit Sorger
Martin Unger
Franz Viehböck

Research Facilities

Facilitating Science

ISTA's nine Scientific Service Units (SSUs) play a key role in helping scientists turn ideas into concrete experiments, developing analytical tools, and ensuring the smooth operation of labs and equipment.

Each of the SSUs at ISTA is headed by a manager and staffed by a team of experts that support scientists with know-how, trainings, and customized research solutions. They also take care of the routine tasks associated with experimental work, from cleaning glassware to ordering chemicals, allowing researchers to focus on their research. The SSUs are organized centrally, a key strategic decision that avoids unnecessary redundancies and guarantees the professional operation and maintenance of the equipment.

The available services are regularly reworked and expanded to meet the changing needs of the Institute. In 2022 alone, there were several significant new equipment investments. The Lab Support Facility installed a small-angle x-ray scattering (SAXS) machine that allows groups to measure material properties on the nanoscale; the Nanofabrication Facility acquired a physical property measurement system (PPMS), which is already helping physics and chemistry groups measure material properties; and the Nuclear Magnetic Resonance Facility purchased a 400 MHz spectrometer that will be used primarily by the new chemistry faculty. In addition, several plant and animal facilities were renovated, increasing the space and techniques available to scientists.

Infected for science

Fever. Cough. Aches. Viruses are usually associated with the symptoms of infection, but it is precisely their amazing ability to infect other cells that makes them so useful to scientists. In particular, scientists replace the virus' genetic material with their desired genes, and use the modified viruses to insert those genes into other cells.

At ISTA, the Virus Services team in the Lab Support Facility focuses on three types of viruses: adeno-associated viruses, the lentivirus, and the rabies virus. The first is used to make targeted cells produce a green (or other color)

Ludek Lovicar, manager of the Electron Microscopy Facility, loads a frozen cell sample into the cryo-focus Ion Beam Aquilos.

“Having a virus facility in house is rather unique and in the Vienna area, we are the only one.”

Flávia Leite, Virology Expert

fluorescent protein, allowing scientists to study the role of a gene within a cell. For instance, the lentivirus has been used by the Siegert group to track microglia immune cells in the brain (see page 41) and by the Sixt group to track immune cells moving through dense tissue (see page 43). Finally, neuroscientists use the rabies virus' ability to infect the nervous system to find individual signal pathways in the brain.

“Having a virus facility in house is rather unique and in the Vienna area, we are the only one”, remarks Flávia Leite, an expert in the team. “Usually, such work is outsourced to companies, but having it done on the ISTA campus allows us to work very closely with the scientists. We can advise the researchers which virus to use and create custom solutions, and we also get valuable feedback from them that allows us to expand our offer.”

New benchmark for cryo-EM

The SSUs not only help in the development of innovative methods and experimental set-ups, they provide access to cutting-edge technology and expertise in using it. In a recent *Nature* paper, Professor Sazanov and his team proposed a universal mechanism of cellular respiration common in most species. Key to these discoveries was the state-of-the-art cryogenic electron microscope (cryo-EM) housed in ISTA's Electron Microscopy Facility. With its help, the Sazanov group can routinely make observations of high enough resolution to see water molecules and identify proton transfer pathways. Moreover, cryo-EM technology is now fast enough that acquiring the data for each structure only takes about a month. This is significantly faster than previous techniques, such as X-ray crystallography, which is what Sazanov used when he started work in this area 20 years ago. Had the group continued to use those methods rather than cryo-EM, “it could have taken another twenty, even thirty years”, says Sazanov.

Preparing the medium for mammalian cells that the technicians use to grow the viruses in the lab.

Comprising 1,500 fish and 400 frog aquariums, the newly renovated Aquatics Facility breeds zebrafish (*Danio rerio*) and African clawed frogs (*Xenopus laevis*).

SSUs at ISTA

- ↗ Electron Microscopy Facility
- ↗ Imaging & Optics Facility
- ↗ Lab Support Facility
- ↗ Library
- ↗ Miba Machine Shop
- ↗ Nanofabrication Facility
- ↗ Nuclear Magnetic Resonance Facility
- ↗ Preclinical Facility
- ↗ Scientific Computing

Technology Transfer

Bridging Science and Innovation

Being a growing campus, there is always some construction going on at ISTA. In 2022, an especially symbolic piece of infrastructure was finished: the Michael Gröller Bridge. It directly connects the campus to the xista Science Park, the Institute's technology park, and represents the many fruitful links between fundamental research, innovative technologies, and businesses. However, this bridging of worlds does not happen by itself: At ISTA, the xista team supports entrepreneurial scientists from ideation to the final product.

Basic research not only expands the frontiers of knowledge, it also lays the groundwork for technological innovation. At ISTA, this translation is supported by xista, the newly formed brand for all of the Institute's innovation efforts. Led by Markus Wanko, it covers topics ranging from entrepreneurial training and founding support to investments and on-site facilities. Wanko remarks, “The new brand xista helps us to communicate all our offers and support structures as a unified innovation ecosystem that bridges research and entrepreneurship.” Professor Bernd Bickel, Vice President for Technology Transfer, adds that “such a comprehensive infrastructure for technology transfer is unique among Austrian research institutions. It not only helps scientists to become founders but also ensures that the Institute will benefit from the technological innovations it develops.”

Enticing innovation

Every good idea for a patent or start-up has to originate somewhere. It must be nurtured, encouraged, and refined if necessary. The xista Tech Transfer, formerly TWIST, team helps scientists to develop and realize their ideas for innovation.

The team raises awareness for potential applications of research by offering scientists the chance to get in contact with successful founders coming from research as well as a variety of training opportunities. They also support scientists along their entrepreneurial journey with their xista Fellowship program. Ingrid Kelly and Bernhard Petermeier from the xista team recount, “In 2022, we worked—among other projects—on ideas for commercializing the ultra-stable lasers developed by Dr. Fritz Diorico and Assistant Professor Onur Hosten; and on developing findings from Assistant Professor Sandra Siegert's group to treat depression with flickering lights.”

Additionally, xista Tech Transfer enables direct contact with industry through their extensive network and the annual Science Industry Day event, where industry representatives meet with ISTA scientists.

Enabling science-based technologies

Once an entrepreneurial idea starts to gain traction, there are a lot of moving parts to take care of. xista Tech Transfer supports the founders in corporate licensing and founding matters as well as in crucial issues such as IP management. New founders also need support and funding to grow their companies, which xista provides through its seed fund xista Science Ventures, formerly called ISTcube. Equipped with 45 million Euro from both public and private investors, the fund has so far invested 15 million Euro into 14 companies working in fields from precision protein conjugation to data analytics platforms for energy management to micro-waveguide technology for augmented reality displays. Wanko adds, "Our investments are bearing fruit and now almost 200 people from over 30 countries work in companies we have invested in. These businesses originate from a variety of academic institutions. The aggregate capital of 100 million Euro available to them is a great reflection of the growth in Austria's spin-off ecosystem." Three of these companies are Neurolentech, Ribbon Biolabs, and Solgate.

Based on an initial xista Fellowship and research by Professor Gaia Novarino and her team, the company Neurolentech develops technologies to aid drug discovery for neurodevelopmental disorders like autism or epilepsy. The aim is to create new diagnostic and treatment strategies for patients for whom no treatment options are currently available. In 2022, Neurolentech received an AWS Seedfinancing grant and has been accepted into Illumina Accelerator for genomic start-ups.

Like a ballerina, the pedestrian walkway curves over the wide street, connecting the main ISTA campus and the xista Science Park, formerly IST Park.

ISTA alumnus Harold de Vladar and his team at Ribbon Biolabs are revolutionizing the production of synthetic DNA by combining chemistry with computer science (see page 33). They synthesize long DNA molecules needed for cancer treatment or vaccines. In 2022, the company raised 18 million Euro in Series A funding and won the Ventures Award at the Falling Walls summit in Berlin.

Solgate is a company also based on research conducted by Novarino and her team in collaboration with CeMM, the Center for Molecular Medicine of the Austrian Academy of Sciences. It develops a platform to facilitate the discovery of new drugs that target solute carrier proteins that transport molecules through membranes in the human body and play an important role in neurological diseases, metabolic disorders, and cancer.

Bickel adds that "xista's portfolio is ever-expanding, and we are currently exploring many new ideas and cooperations. We also recently signed a multi-year agreement with Boehringer Ingelheim based on Assistant Professor Matthew Robinson's work on modeling large-scale medical record data."

Providing space for Growth

After new start-up founders have developed their idea and secured funding, they also require a place to work. The xista Science Park, formerly called IST Park, offers exactly that. Opened in 2019 just across the street from the ISTA campus, its two buildings house not only some of ISTA's own spin-offs but also companies from the xista Science Ventures portfolio.

"xista Science Park, developed in cooperation with Lower Austria's business agency ecoplus, is a great success. This year, we rented our second building out fully, and we are already planning the next expansion", Wanko is happy to announce.

This brings us back to the Michael Gröller Bridge opened in 2022. Designed by the award-winning Catalan team RCR Arquitectes, its sweeping arch symbolizes the dynamic connections formed here between research and application, academia and entrepreneurship, and between ideation and realization.

"Relating is the most important action. And this is the action that this slender footbridge performs."

Ramón Vilalta, Architect of the Michael Gröller Bridge

A founder, a board member, a speaker: Anton Zeilinger has helped shape the Institute from the beginning.

Highlight

A Nobel Prize for ISTA Founder

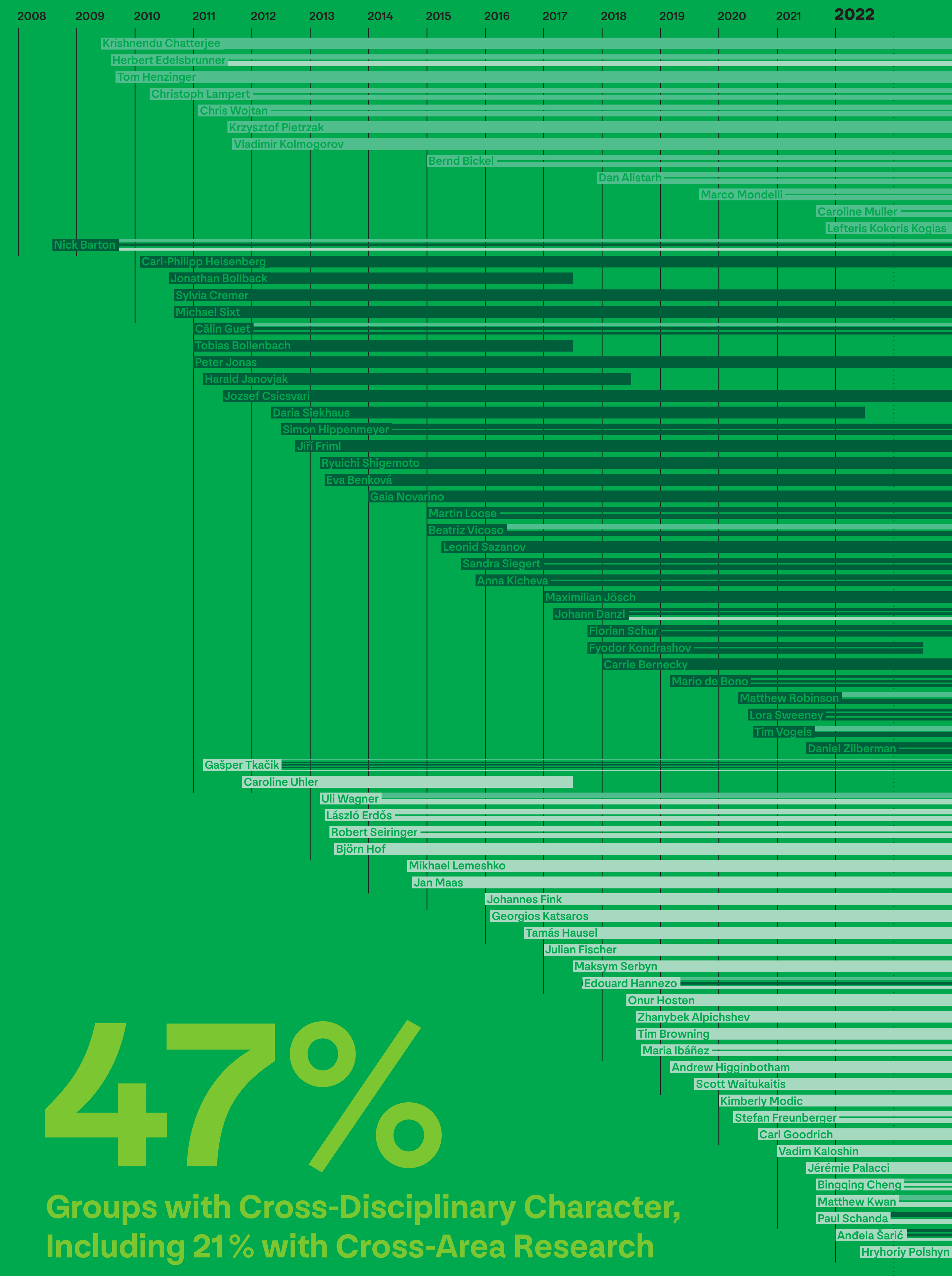
For their pioneering experiments in quantum physics, Alain Aspect, John F. Clauser, and Anton Zeilinger were awarded the 2022 Nobel Prize in Physics. Anton Zeilinger, of the University of Vienna and the Austrian Academy of Sciences, not only made Austria one of the global centers of frontier quantum research, he also lit the initial spark to found ISTA.

"The Nobel Prize is the most visible honor in international science. This recognition is not only overdue, it is also hugely important for Austrian science", congratulates founding President Thomas A. Henzinger. "Though we cannot know what will arise from basic research, Anton's work—and the work of countless others—shows that funding curiosity-driven research is essential for innovation and advancement as a society."

Anton Zeilinger first laid the groundwork for his experiments decades ago. At the time, there were no applications—Zeilinger was guided purely by his desire for knowledge. Now, his breakthroughs have unraveled profound features of our natural world—a striking example of the impact and significance of curiosity-based, fundamental science. In 2002, Zeilinger's conviction in the power of basic research further led him to propose founding an excellence-oriented, globally competitive institution in Austria, where top scientists would be able to pursue their blue-sky research without limits. Four years later, ISTA was founded with Zeilinger as vice-chair of the Board of Trustees. Since then, basic research on campus has led to groundbreaking science in multiple areas, and the freedom to work across disciplines has given rise to highly productive collaborations (see pages 38, 44, and 48). In fact, six research groups on campus work in the field of quantum physics, advancing also what started in the laboratories of this year's physics Nobel laureates. See page 47 for more about the research of three of these groups.

Pioneering Excellence

Outstanding science depends on exceptional scientists, and ISTA seeks to recruit the best. From 4 research groups in 2009 to 68 in 2022, the faculty has grown in leaps and bounds, leading groups that push our understanding and knowledge forward.



47%

Groups with Cross-Disciplinary Character, Including 21% with Cross-Area Research

New Professors

Contracts signed as of December 31, 2022

Faculty recruiting is critical to the success of the Institute: Research conducted on campus is exceptional because the Institute hires exceptional scientists. This year, eight new professors signed contracts and will join ISTA over the course of 2023.

The professors joining in 2023 will strengthen the Institute's research portfolio in biology, chemistry, computer science, and earth science. This includes the first senior hire from ISTA's role model, the Weizmann Institute of Science in Israel. Finally, two astrophysicists will establish a new research field on campus. With these eight new hires, ISTA reaches the halfway point to the eventual goal of 150 professors by 2036.

Though talent is equitably dispersed, representation from many groups is low and demographics are lopsided at ISTA and many other institutes. ISTA is committed to changing this. Specific measures are in place to encourage applications from women faculty and minimize bias in hiring decisions. These efforts have yielded some success already: Half of the new professors hired this year are women. Furthermore, in November 2022, ISTA signed both the Agreement on Reforming Research Assessment (CoARA) as well as the San Francisco Declaration on Research Assessment (DORA). Both signatures represent a commitment of the Institute to evaluate, and if necessary change, the assessment practices for research and researchers, which will ultimately maximize the quality and impact of ISTA's research.

Lisa Bugnet
Stellar Dynamics and Asteroseismology

Astronomy
Data Science

Understanding the evolution and dynamics of stars is key to the study of most astronomical objects, from exoplanets to galaxies. Recent advances in asteroseismology, a branch of stellar physics that analyzes oscillations of stars induced by stationary waves, have opened up questions into our understanding of stellar evolution, which in turn would have far-reaching consequences for our understanding of the universe.

Lisa Bugnet uses asteroseismology to understand the evolution of stars and their dynamical processes. At ISTA, the Bugnet group will combine theory, models, and observational constraints from asteroseismology to increase our understanding of stellar magnetic fields, essential but poorly characterized.

Bugnet earned her doctorate in 2020 from the French Alternative Energies and Atomic Energy Commission (CEA) in Saclay, France, then continued her research as a fellow at the Center for Computational Astrophysics of the Flatiron Institute in New York, USA.

Lisa Bugnet will join ISTA in January 2023.

Xiaoqi Feng
Reproductive Genetics and Epigenetics

Cell Biology

Epigenetics is the study of changes in how genes are expressed, without changes in the underlying genome. Understanding germlines, the cells that contain the genetic information that is passed down from one generation to the next, is essential for understanding epigenetics because they mediate inheritance and undergo large-scale epigenetic changes. Plant germlines are particularly well suited to study the core principles of epigenetics and sexual reproduction. They are also of enormous practical significance because they produce the seeds that comprise most of the world's staple food.

Xiaoqi Feng seeks to understand the molecular mechanisms and biological functions of these epigenetic changes, as well as how environment-induced epigenetic memories are transmitted and/or erased, among other open questions.

Prior to joining ISTA, Feng was a group leader and professor at the John Innes Centre in Norwich, UK (2014–2022) and a postdoc at the University of California, Berkeley, USA (2011–2014). She earned her PhD in plant sciences in 2010 at the University of Oxford, UK.

Xiaoqi Feng will join ISTA in January 2023.

Monika Henzinger
Algorithms

Computer Science

Locating the clusters—sets of points that are close to each other—in datasets is a key problem in unsupervised learning. However, classic approaches to this problem assume the data are static, even though in many applications, the points are constantly changing and evolving.

Monika Henzinger is interested in developing efficient dynamic clustering algorithms. They account for these changes while maintaining clustering. An additional consideration when dealing with real-world applications is privacy. Differential privacy is a way to share the large patterns (such as clusters) in data while withholding enough information to protect the privacy of the individuals. Henzinger and her group will study differential privacy in the context of dynamic sets.

Before joining ISTA, Monika Henzinger was a professor at the University of Vienna, Austria. She earned her PhD in 1993 from Princeton University and was an assistant professor at Cornell University, a researcher at Digital Equipment Corporation, the Director of Research at Google and a professor at EPFL, Switzerland, before moving to Austria.

Monika Henzinger will join ISTA in March 2023.

Martin Hetzer
Protein Homeostasis and Aging

Cell Biology
Neuroscience

Old age is the major risk factor for the development of neurodegenerative diseases such as Alzheimer's disease. Martin Hetzer researches the impact of the cumulative changes during adulthood on health and the development of disease, focusing on cell maintenance and repair mechanisms. Of particular interest is understanding how non-dividing cells such as neurons function over the course of a lifetime and how cells lose control over the quality and integrity of proteins and important cell structures during aging. His ultimate goal is to utilize these mechanisms to delay age-related decline of organs with limited cell renewal such as the brain, pancreas, and heart.

Hetzer applies genomics, proteomics and advanced imaging techniques to pose questions about how adult tissues are maintained. In addition to his role as group leader, he is president of ISTA.

In 1997, Hetzer earned his PhD in biochemistry and genetics from the University of Vienna, Austria, and completed postdoctoral work at the European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany. He joined the faculty at the Salk Institute in San Diego, California, USA in 2004 and became a full professor in 2011.

Martin Hetzer will join ISTA in January 2023.

Rafal Klajn
Catalysis and Synthetic Methodology

Chemistry

Nature has long impressed chemists with its ability to synthesize complex molecules and exquisite inorganic nanostructures with unprecedented precision and yield. What natural systems consistently exploit—which is still fundamentally different from how synthetic chemists perform reactions—is the aspect of nanoscale confinement.

Rafal Klajn develops novel materials and supramolecular assemblies incorporating nanoconfined spaces; he then studies the behavior of chemical species within these spaces in order to create efficient ways to carry out otherwise challenging chemical transformations. His group also designs and synthesizes stimuli-responsive systems and materials, with the long-term goal of developing new energy-efficient and environmentally friendly materials.

Klajn was born and raised in Poland and holds a PhD from Northwestern University. In 2009, he joined the Weizmann Institute of Science as a tenure-track assistant professor and was later promoted to associate and full professor.

**Rafal Klajn
will join ISTA in August 2023.**

Jorryt Matthee
Astrophsyics of Galaxies

Astronomy

Small perturbations in the initial density distribution resulting from the Big Bang lead to the formation of galaxies in the universe. While the physics of gravitational collapse is well understood, the finer details of many galactic processes, such as the formation of stars, supernova explosions, and the growth of supermassive black holes, are poorly understood—even though they have significant impact on the fate of galaxies as well as the stars and planets within them.

Jorryt Matthee investigates the physical mechanisms that determine how galaxies and their constituents form and evolve. At ISTA, Matthee and his group will use observations from some of the largest telescopes on Earth and in space. They will look inside distant galaxies and probe the properties of the young massive stars responsible for the creation of the majority of heavy elements and the production of most of the ionizing radiation in the early universe, and their impact on interstellar gas clouds.

After earning his PhD in 2018 from Leiden University in the Netherlands, Matthee spent five years at ETH Zurich, Switzerland, as a postdoctoral fellow before joining ISTA as an assistant professor.

**Jorryt Matthee
will join ISTA in September 2023.**

Francesca Pellicciotti
Cryosphere and mountain hydrosphere

Data Science

Earth Science

Models are a powerful tools to understand the relationships between Earth's climate and surface features. Francesca Pellicciotti models the interactions of the climate—especially a changing one—and glaciers, snow, and water resources. Her work includes studying glacier response, high elevation water resources and water security; debris-covered glaciers and their response to climate; snow and its significance for catchments water balance; and green-blue water interactions in high mountains. Her research bridges the scales, from single glaciers to entire mountain regions—field work has taken her from Nepal's Himalayas to Chile's Andes. She analyzes data from field research and remote sensing with numerical models and data science.

Pellicciotti earned her PhD in 2004 from ETH Zurich in Switzerland, where she continued as postdoc and senior scientist before moving to the UK as associate professor at Northumbria University, Newcastle, in 2015. She returned to Switzerland in 2018 with an ERC Consolidator Grant to study the anomalous mass losses of High Mountain Asia glaciers and water resources, as group leader of the HIMAL (High Mountain Glaciers and Hydrology) group at the Swiss Federal Institute for Forest, Snow and Landscape Research (ETH Domain).

**Francesca Pellicciotti
will join ISTA in March 2023.**

Bartholomäus Pieber
Catalysis and Synthetic Methodology

Chemistry

Nature uses light as a sustainable energy source to convert raw materials into complex molecules. From a synthetic chemist's perspective, light is an ideal reagent. Unlike conventional reagents, light is non-toxic and generates no waste.

The group of Bart Pieber seeks to unravel the full potential of visible light for synthetic organic chemistry by developing new photocatalysts and methods. His research is driven by curiosity and the understanding of reaction mechanisms and photophysical properties of photocatalysts. The PieberLab is particularly interested in heterogeneous photocatalysis using semiconductors and the development of methods in which the wavelength serves as a parameter to control the outcome of reactions.

Pieber earned his PhD in 2015 at the University of Graz, Austria. He then spent two years as a postdoc at the Max Planck Institute of Colloids and Interfaces in Potsdam, Germany, and subsequently started his independent career as a group leader. Since 2020, he has also held a lecturer position at the University of Potsdam. In 2022, he spent time as a visiting professor at the California Institute of Technology in Pasadena, USA.

**Bartholomäus Pieber
will join ISTA in June 2023.**

Research Groups

Since its founding, ISTA has hired approximately six faculty members each year on the sole basis of research promise and excellence. Upon recruitment, professors as well as assistant professors start their own research group. By the end of 2022, these 68 groups are conducting research.

While clear lines between disciplines do not reflect the interwoven nature of scientific inquiry, ISTA's breadth of faculty expertise can be contracted into three major areas: life sciences, mathematical and physical sciences, information and system sciences. More fine-grained disciplines may be attributed to groups, however, many identify with several of them, as their projects employ any tool to gain insight.

Faculty calls have always been independent of fields; yet, recruitment at ISTA acknowledges the positive effect of "clusters" within fields, as they enable discourse, which are beneficial to developing innovative ideas. By 2036, the Institute envisions hosting around 150 research groups, further expanding its research spectrum with outstanding scientists, who bring new perspectives.

Alistarh Group
Distributed Algorithms and Systems

Computer Science
Data Science

Distribution has been one of the key trends in computing over the last decade. Processor architectures are multi-core, while large-scale systems for machine learning and data processing can be distributed across several machines or even data centers. The Alistarh group works to enable these applications by creating algorithms that scale—that is, they improve their performance when more computational units are available.
The shift to distributed computing opens exciting questions: How do we design algorithms to extract every last bit of performance from the current generation of architectures? How do we design future architectures to support more scalable algorithms? Are there clean abstractions to render high-performance distribution accessible to programmers? The group seeks to answer these questions, and focuses on designing efficient, practical algorithms for fundamental problems in distributed computing, understanding the inherent limitations of distributed systems, and on developing new ways to overcome these limitations.

Current projects: Distributed machine learning; Concurrent data structures and applications; Molecular computation

Dan Alistarh

Career: since 2022 Professor, ISTA
2017–2022 Assistant Professor, ISTA
2016–2017 "Ambizione" Fellow, Computer Science Department, ETH Zurich, Switzerland
2014–2016 Researcher, Microsoft Research and Morgan Fellow, University of Cambridge, UK
2012–2013 Postdoc, Massachusetts Institute of Technology, Cambridge, USA
2012 PhD, EPFL, Lausanne, Switzerland

Alpichshev Group
Condensed Matter and Ultrafast Optics

Physics

To understand a complex system, it is often useful to bring it out of equilibrium, as the recovery dynamics will reveal a great deal about its inner workings. The Alpichshev group uses ultra-fast optical methods to understand the physical mechanisms underlying some of the extremely complicated phenomena in many-body physics.
A key problem in modern physics is to understand the behavior of a large number of strongly interacting particles. Such systems often feature unique properties such as high-temperature superconductivity, but the origin of these behaviors is unclear. The main difficulty is that these "strongly correlated" properties arise in the context of a large number of competing phases, which makes it difficult to determine the role of each factor. The Alpichshev group circumvents this problem by using ultrashort laser pulses to selectively perturb and probe the individual degrees of freedom in a strongly correlated material and study the system in the resulting transient state. The resulting information can be used to reconstruct the microscopic mechanisms behind complex phenomena.

Current projects: Nonlinear response in hybrid lead halide perovskites; Nonlinear THz spectroscopy of quantum spin liquids; Ultrafast dissipative processes in correlated electron systems below Planckian level

Zhanybek Alpichshev

Career: since 2018 Assistant Professor, ISTA
2017–2018 Visiting Scientist, Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany
2012–2017 Postdoctoral Associate, Massachusetts Institute of Technology, Cambridge, MA, USA
2012 PhD, Stanford University, Palo Alto, USA

Barton Group
Evolutionary Genetics

Data Science
Evolution & Ecology
Mathematics

The Barton group develops mathematical models to probe into fundamental issues in evolution. For example, how do new species form, what limits adaptation, and what shapes the genetic system?
Nick Barton and his group study diverse topics in evolutionary genetics. The main focus of their work is the effects of natural selection on many genes and the evolution of populations that are distributed across space. They develop statistical models for the evolution of complex traits, which depend on the combined effects of very many genes. Working with other groups at ISTA, they study the evolution of gene regulation, using a thermodynamic model of transcription factor binding. A substantial component of the group's work is a long-term study of the hybrid zone between two populations of snapdragons (*Antirrhinum*) that differ in flower color. This combines detailed field observation with genetic data to estimate population structure and fitness variation over multiple scales. The approach serves as a test-bed for developing ways to infer selection and demography from DNA sequence.

Current projects: Evolution of complex traits; Analysis of selection experiments; Understanding genealogies in space and at multiple loci; Inference from DNA sequence; Population structure and hybridization in *Antirrhinum*

Nick Barton

Career: since 2008 Professor, ISTA
1990–2008 Reader and Professor, University of Edinburgh, UK
1982–1990 Lecturer and Reader, University College London, UK
1980–1982 Demonstrator, Cambridge University, UK
1979 PhD, University of East Anglia, Norwich, UK

Benková Group
Plant Developmental Biology

Cell Biology

Plant hormones "set in motion" a myriad of physiological processes that influence and modulate each other in an intricate network of interactions. The Benková group seeks to untangle this network and understand its molecular basis.
Local heterogeneities in water and nutrient availability, sudden changes in temperature, light or other stressors trigger dramatic changes in plant growth and development. Multiple hormonal signaling cascades interconnected into complex networks act as translators of these exogenous signals in plant adaptive responses. The focus of the Benková group is on how hormonal networks are established, maintained, and modulated to control specific developmental outputs. Their work has contributed to understanding how plant development is internally regulated by plant hormones and identified several important mechanisms that connect individual hormonal pathways into a complex regulatory network underlying plant adaptation to environmental inputs.

Current projects: Convergence of auxin and cytokinin hormonal pathways; Identification of hormonal cross-talk components by genetic approaches; Hormonal crosstalk driven nutrient-dependent root development

Eva Benková

Career: since 2016 Professor, ISTA
2013–2016 Assistant Professor, ISTA
2011–2013 Group Leader, Central European Institute of Technology, 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

Bernecky Group
RNA-Based Gene Regulation

Biochemistry

The regulated expression of genetic material is one of the most basic processes of a cell, affecting everything from organism development to environmental response. Through structural studies of the involved complexes, the Bernecky group works to unravel the gene expression regulatory networks that employ RNA as an intermediate.
RNA is an important focal point for the regulation of gene expression. Both protein-coding and noncoding RNAs are integral components of diverse regulatory pathways and often act together with protein cofactors. Despite their importance, an understanding of the mechanisms of action of the involved RNA-protein complexes is lacking. Many of these RNA-containing complexes are flexible, modular, and lowly abundant. For such challenging targets, cryo-electron microscopy has emerged as a particularly powerful tool for the determination of near-atomic structures while simultaneously providing insight into their dynamics. Using this and related methods, the Bernecky group aims to understand how RNA-protein complexes assemble and regulate cellular RNA metabolism.

Current projects: Molecular basis of transcriptional regulation; Regulation of mammalian transcription by noncoding RNA; Substrate recognition by RNA modifying enzymes; Roles of A-to-I editing in dsRNA recognition

Carrie Bernecky

Career: since 2018 Assistant Professor, ISTA
2011–2017 Postdoc, Ludwig Maximilian University Munich and Max Planck Institute for Biophysical Chemistry, Göttingen, Germany
2010–2011 Postdoc, University of Colorado Boulder, USA
2010 PhD, University of Colorado Boulder, USA

Bickel Group
Computer Graphics and Digital Fabrication

Computer Science
Data Science

We are currently witnessing the emergence of novel, computer controlled output devices that provide revolutionary possibilities for fabricating complex, functional, multi-material objects and metamaterials with stunning optical and mechanical properties.
Bernd Bickel is a computer scientist interested in computer graphics and its overlap with animation, biomechanics, material science, and digital fabrication. His group seeks 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: developing novel modeling and simulation methods, and investigating efficient representation and editing algorithms for materials and functional objects.

Current projects: Computational synthesis of metamaterials; Soft robotics; Interactive design systems; Design of cyber-physical systems

Bernd Bickel

Career: since 2021 Vice President for Technology Transfer, ISTA
since 2020 Professor, ISTA
2015–2020 Assistant Professor, ISTA
2012–2014 Research Scientist and Research Group Leader, Disney Research Zurich, Switzerland
2011–2012 Visiting Professor, TU Berlin, Germany
2011–2012 Postdoc, Disney Research Zurich, Switzerland
2010 PhD, ETH Zurich, Switzerland

Browning Group
Analytic Number Theory and its Interfaces

Mathematics

What is the connection between adding and multiplying whole numbers? This is a surprisingly deep question with several interpretations. One natural extension studies the sequence of integers that arise as solutions to a polynomial equation with integer coefficients, i.e. a Diophantine equation. The Browning group works on understanding such sequences, using a blend of analytic, geometric, and algebraic methods.
Low-dimensional Diophantine equations have been heavily used in cryptography, but the properties of higher-dimensional Diophantine equations remain largely mysterious. Hilbert's 10th problem asks for an algorithm to decide if a given Diophantine equation has integer solutions. Mathematical logic has revealed this to be an impossible dream, but does such a procedure exist if we just seek rational solutions? Moreover, when solutions are known to exist, there are deep conjectures that connect their spacing to the intrinsic geometry of the equation. The Browning group is involved in actively expanding the available toolkit for studying these problems and their generalizations.

Current projects: Moduli space of rational curves on hypersurfaces of low degree; Rational points on Fano varieties; Manin's conjecture for orbifolds; Motivic arithmetic statistics; Integral points of bounded height; Equidistribution of lattices

Tim Browning

Career: since 2018 Professor, ISTA
2012–2019 Professor, University of Bristol, UK
2008–2012 Reader, University of Bristol, UK
2005–2008 Lecturer, University of Bristol, UK
2002–2005 Postdoctoral Research Fellow, University of Oxford, UK
2001–2002 Postdoctoral Research Fellow, Université de Paris-Sud, Orsay, France
2002 PhD, Magdalen College, University of Oxford, UK

Chatterjee Group
Computer-Aided Verification, Game Theory

Computer Science

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 studies interactive problems in decision-making, and can be used to study problems in fields from logic to biology. The Chatterjee group is interested in game theory's application in formal verification, and evolutionary game theory. Game theory in formal verification involves the algorithmic analysis of various forms of games played on graphs, where the graph models a reactive system. This framework allows for the effective analysis of many important questions and helps to develop robust systems. The Chatterjee group also works on algorithmic aspects of evolutionary game theory on graphs, where the graph models a population structure. Here, their goals are to better understand games and to develop new algorithms.

Current projects: Quantitative verification; Stochastic game theory; Modern graph algorithms for verification problems; Evolutionary game theory

Krishnendu Chatterjee

Career: since 2014 Professor, ISTA
2009–2014 Assistant Professor, ISTA
2008–2009 Postdoc, University of California, Santa Cruz, USA
2007 PhD, University of California, Berkeley, USA

Cheng Group
Computational Materials Science

Chemistry
Data Science
Physics

The building blocks of matter are electrons and atomic nuclei, whose behavior follows the laws of quantum mechanics. By solving the Schrödinger equation, one can predict the properties of any material, including existing or novel compounds yet to be synthesized. However, there is a catch.
As the number of electrons and nuclei increases, the complexity involved in solving the equation soon becomes intractable even with the fastest supercomputers. In fact, atomistic simulations based on quantum mechanics are still unaffordable for systems with more than a few hundred atoms, or for a time period longer than a nanosecond. The Cheng group is particularly interested in developing methods to extend the scope of atomistic simulations, in order to understand and predict properties that are hard to access. The group deploys and designs a combination of techniques encompassing machine learning, enhanced sampling, path-integral molecular dynamics, and free energy estimation. The systems of study include energy materials, aqueous systems, and matter under extreme conditions.

Current projects: Machine-learning potentials for functional materials; Transport phenomena at the microscale; Efficient statistical learning of materials properties; Developing advanced methods for statistical mechanics and atomistic simulations

Bingqing Cheng

Career: since 2021 Assistant Professor, ISTA
2020–2021 Departmental Early Career Fellow, University of Cambridge, UK
2019 Junior Research Fellow, Trinity College, University of Cambridge, UK
2019 PhD EPFL, Lausanne, Switzerland

Cremer Group
Social Immunity

Evolution & Ecology

Social insects fight disease as a collective. Together, they prevent and treat infections and alter their social behaviors to prevent epidemics. The Cremer group uses ants as a model to study how collective protection arises at the colony level from the interplay between individual immunity and social interactions.
Like all social groups with frequent and close social interactions, social insects run the risk of high transmission of infectious disease through their colony. Ants effectively counteract this threat by collectively performing sanitary care behaviors, along with their individual immune defenses. Ants not only detect infection by perceiving disease symptoms, but also react to the presence of a pathogen by cleaning the affected individual. They detect the pathogen by its chemical cues, like the fungal membrane component ergosterol. The pathogens, on the other hand, reduce the cues they emit to hide from detection by the grooming ants.

Current projects: Collective hygiene in ant societies; Social interaction networks and epidemiology; Disease resistance and tolerance; Costs and benefits of social immunization

Sylvia Cremer

Career: since 2015 Professor, ISTA
2010–2015 Assistant Professor, ISTA
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

Csicsvari Group
Systems Neuroscience

Neuroscience

Memory formation is crucial for learning. This process of encoding, storing, and ultimately recalling memories involves complex interactions between various brain regions and neurons in embedded circuits that form complex codes The Csicsvari group studies how learning is implemented in the brain.
During learning, new memories are acquired and then consolidated to ensure their successful recall later. The Csicsvari group focuses on understanding how learning leads to memory formation in neuronal circuits by investigating the neuronal system mechanisms of memory formation and stabilization. The researchers also investigate the mnemonic role of neuronal populations and their interactions in brain areas involved in spatial memory processing. The group seeks to understand how neuronal circuits process information and form spatial memories by recording the activity of many neurons in different brain regions during spatial learning tasks and sleep. Using optogenetic methods, the researchers selectively manipulate neuronal activity in different brain areas.

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

Jozsef Csicsvari

Career: since 2011 Professor, ISTA
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
1999 PhD, Rutgers University, New Brunswick, USA

Danzl Group
High-Resolution Optical Imaging for Biology

Cell Biology
Neuroscience
Physics

How can we decode the molecular architecture of biological systems? How can we analyze living cells and tissues across spatial and temporal scales? The central aim of the Danzl lab, an interdisciplinary team of physicists, biologists, computer scientists, and neuroscientists, is to shed light on problems of biological and medical relevance by developing and using a set of advanced light microscopy tools.
The Danzl group explores and extends the possibilities of optical imaging, including approaches that enable resolution better than the optical diffraction limit of about half the wavelength of light or 200 nm. With resolution reaching into the nanometer range and the capability to analyze cells in their native tissue context, the group aims to extract new information from biological specimens. To this end, they work toward the development of novel imaging approaches, building on their expertise in physics and high-resolution imaging integrated with state-of-the-art technologies to manipulate cells and tissues, label them, and extract the most useful information from the imaging data.

Current projects: Analysis of brain tissue across spatial scales; Optical imaging of cell and tissue ultrastructure; Minimally perturbing high-resolution imaging

Johann Danzl

Career: since 2017 Assistant Professor, ISTA
2012–2016 Postdoc, Department of NanoBiophotonics, Max Planck Institute for Biophysical Chemistry, Göttingen, Germany
2010–2011 Postdoc, Institute for Experimental Physics, University of Innsbruck, Austria
2010 PhD, University of Innsbruck, Austria
2005 MD, Medical University of Innsbruck, Austria

de Bono Group
Genes, Circuits, and Behavior

Biochemistry
Cell Biology
Neuroscience

Neurons are highly specialized cells and many fundamental questions about their organization, function, and plasticity remain unaddressed. The de Bono group seeks to discover and then dissect basic molecular mechanisms that underpin the functions of neurons and neural circuits.
The group initiates many of their studies in the roundworm *C. elegans*, because of its advantages for molecular and cellular neuroscience. Each neuron of this animal can be identified and visualized in vivo by selectively manipulating it using transgenes and monitoring its activity with genetically encoded sensors. Powerful genetics and advanced genomic resources make high-throughput forward genetics and single neuron profiling possible. Genetics are complemented with biochemistry to get at the molecular mechanisms that are usually conserved from worm to human. The group aims to take discoveries made in the worm into mammalian models.

Current projects: Global animal states; The neural unknome; Neuroimmune signaling

Mario de Bono

Career: since 2019 Professor, ISTA
1999–2019 Programme Leader, MRC Laboratory of Molecular Biology, Cambridge, UK
1995–1999 Postdoc, UCSF, San Francisco, USA
1995 PhD, University of Cambridge, UK

Edelsbrunner Group
Algorithms, Computational Geometry, and Computational Topology

Computer Science
Mathematics

Understanding the world in terms of patterns and relations is the undercurrent in computational geometry and topology; it is also the broad research area of the Edelsbrunner group.
While geometry measures shapes, topology focuses on how shapes are connected. There are however deep connections, such as Crofton's formula in integral geometry, which blur the difference. The Edelsbrunner group approaches the subject from a mathematical as well as computational point of view, keeping connections to applications in the sciences in mind. Candidate areas for fruitful collaborations include structural molecular biology, astrophysics, and—more generally—machine learning and data analysis.

Current projects: Discretization in geometry and dynamics; Algebraic footprints of geometric features in homology; Alpha shape theory extended

Herbert Edelsbrunner

Career: since 2009 Professor, ISTA
2004–2012 Professor of 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

Erdős Group
Mathematics of Disordered Quantum Systems and Matrices

Mathematics
Physics

How do energy levels of large quantum systems behave? What do the eigenvalues of a typical large matrix look like? Surprisingly, these very different questions have the same answer!
Large complex systems tend to develop universal patterns that represent their essential characteristics. A pioneering vision of Eugene Wigner was that the distribution of the gaps between energy levels of complicated quantum systems depends only on the basic symmetry of the model and is otherwise independent of the physical details. However, this has never been rigorously proved for any realistic physical system. The Erdős group took up the challenge to verify Wigner's vision with full mathematical rigor. Starting from the simplest model, a large random matrix with independent identically distributed entries, the group can now deal with arbitrary distributions and even matrices with correlated entries. The mathematics developed along the way will extend the scope of random matrix theory and will likely be used in many applications beyond quantum physics.

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

László Erdős

Career: since 2013 Professor, ISTA
2003–2013 Chair of Applied Mathematics, Ludwig Maximilian University of 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, Princeton University, USA

Fink Group
Quantum Integrated Devices

Physics

The Fink group's research is positioned between quantum optics and mesoscopic condensed matter physics. The team studies quantum physics in electrical, mechanical, and optical chip-based devices with the goal of advancing and integrating quantum technology for simulation, communication, metrology, and sensing.
One of the Fink group's goals is to develop a microchip-based router that will be able to convert a microwave signal to an optical signal with near unity efficiency. With such devices, the researchers seek to perform quantum communication with superconducting circuits and telecom wavelength photons. In one project, the group uses a qubit to create a single photon state. With the router, this microwave photon is converted into an optical photon, which can then be transmitted over long distances using low-loss optical fiber. The group will also use this technique to entangle microwave and optical photons—an important step toward realizing worldwide quantum networks.

Current projects: Quantum electro- and optomechanics; Quantum microwave photonics; Ultra-high impedance physics for hardware protected qubits; Multi-qubit quantum electrodynamics; Resonant nonlinear optics

Johannes Fink

Career: since 2021 Professor, ISTA
2016–2021 Assistant Professor, ISTA
2015–2016 Senior Staff Scientist, California Institute of Technology, Pasadena, USA
2012–2015 IQIM Postdoctoral Research Scholar, California Institute of Technology, Pasadena, USA
2011–2012 Postdoctoral Research Fellow, ETH Zurich, Switzerland
2010 PhD, ETH Zurich, Switzerland

Fischer Group

Theory of Partial Differential Equations, Applied and Numerical Analysis

Mathematics

Diverse phenomena such as the motion of fluids or elastic objects, the evolution of interfaces, or the physics of quantum mechanical particles are described accurately by partial differential equations. The Fischer group works on the mathematical analysis of partial differential equations that arise in the sciences, and their research connects to areas like numerical analysis and probability.

Partial differential equations are a fundamental tool for the description of many phenomena in the sciences. The Fischer group works on the mathematical aspects of partial differential equations (PDEs). One of the group's main themes is the mathematical justification of model simplifications. For example, an elastic material with a highly heterogeneous small-scale structure may be approximated as a homogeneous material, or a fluid with low compressibility as incompressible. To justify such approximations, the group derives rigorous estimates for the approximation error. The techniques they employ connect the analysis of PDEs with adjacent mathematical areas like numerical analysis and probability.

Current projects: Effective behavior of random materials; Evolution of interfaces in fluid mechanics and solids; Fluctuating hydrodynamics and SPDEs; Entropy-dissipative PDEs

Julian Fischer

Career: since 2022 Professor, ISTA
2017–2022 Assistant Professor, ISTA
2014–2016 Postdoc, Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany
2013–2014 Postdoc, University of Zurich, Switzerland
2013 PhD, University of Erlangen-Nürnberg, Germany

Freunberger Group

Materials Electrochemistry

Chemistry
Physics

Life uses electron transfer reactions to—among other things—store or retrieve energy and produce useful chemicals and materials. The Freunberger group works on electrochemical materials sciences with broadly similar goals.

The group's primary research interest lies in the fundamental science of electron and ion conducting and redox active materials (inorganic, organic, and polymeric) as well as their mutual interactions in the working environment of electrochemical devices. They focus on energy storage devices such as rechargeable batteries, and their results find use in clean, efficient, and sustainable energy sources. The foundations of the group's research are: the synthesis of new conducting and redox active materials; a fundamental understanding of charge carrier transport and electrochemical reactions; advanced physico-chemical and spectroscopic investigations to understand the mutual behavior of the materials in their working environment; surface and interface processes; and the application in electrochemical devices.

Current projects: Oxygen redox chemistry and singlet oxygen; Sulphur electrochemistry; Organic electrode materials; Non-aqueous electrolytes and Interphases; Organic mixed conductors; Electrosynthesis; Operando spectroscopy

Stefan Freunberger

Career: since 2020 Assistant Professor, ISTA
2012–2020 Researcher and Group Leader, TU Graz, Austria
2014 Visiting Professor, University of Montpellier, France
2008–2012 Postdoc and Early Career Fellow, University of St Andrews, UK
2007 PhD, ETH Zurich, Switzerland

Friml Group

Developmental and Cell Biology of Plants

Cell Biology

When conditions get tough, animals typically fight or flee, but plants are rooted in their environment, and have thus become remarkably adaptable. The Friml group investigates the mechanisms underlying plants' adaptability during embryonic and postembryonic development.

Plants are highly adaptive and able to modify development and physiology to environmental changes; they can easily regulate growth, initiate new organs or regenerate tissues. Many of these developmental events are mediated by the plant hormone auxin. The Friml group investigates the unique properties of auxin transport and signaling, which can integrate both environmental and endogenous signals. Employing methods ranging from molecular physiology to mathematical modeling, the group focuses on auxin transport, cell polarity, endocytic recycling as well as non-transcriptional mechanisms of signaling. The researchers gain insights into the mechanisms governing plant development and have shown how signals from the environment are integrated into plant signaling and result in changes to plant growth and development.

Current projects: Polar auxin transport; Cell polarity and polar targeting; Endocytosis and recycling; Non-transcriptional mechanisms of signaling

Jiří Friml

Career: since 2013 Professor, ISTA
2007–2012 Full Professor, University of Ghent, Belgium
2006 Full Professor, University of Göttingen, Germany
2002–2005 Group Leader, Habilitation, University of Tübingen, Germany
2002 PhD, Masaryk University, Brno, Czech Republic
2000 PhD, University of Cologne, Germany

Goodrich Group

Theoretical and Computational Soft Matter

Physics

How can materials dynamically control or remodel their own internal structure to affect their behavior? How can the statistics of structural disorder be biased to produce non-trivial properties? Such questions are a key step in the development of synthetic biology, where non-biological materials and nanoscale machines operate with a complexity and functionality found only in biology.

The Goodrich group uses computational and theoretical tools to discover basic soft matter principles that could one day lead to new functional materials as well as deepen our understanding of complex biological matter. The goal is first to understand general assembly mechanisms, and then work with experimentalists to test these ideas. The group deploys and develops a number of numerical techniques, from molecular dynamics to machine learning. Specifically, the researchers are at the forefront of the development of differentiable physics models, which provide a new and powerful way to explore high-dimensional systems and discover complex, non-trivial phenomena.

Current projects: Self-assembly of disordered materials; Kinetic/functional assembly; Differentiable physics models; Highly parameterized systems

Carl Goodrich

Career: since 2020 Assistant Professor, ISTA
2015–2020 Postdoc, Harvard University, Cambridge, USA
2015 PhD, University of Pennsylvania, Philadelphia, USA

Guet Group

Systems and Synthetic Biology of Genetic Networks

Cell Biology
Data Science
Evolution & Ecology

Living systems are characterized by connections and interactions across many scales—from genes to organelles, from cells to ecologies— as parts of networks. What basic rules, if any, do these networks follow? The Guet group studies the molecular biology and evolution of gene regulatory 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 from timescales of a few seconds to the time it takes a cell to divide and beyond. By studying existing networks and constructing synthetic networks in living cells, the group works to understand how molecular mechanisms interact with evolutionary forces that ultimately shape each other. They use a variety of classical and modern experimental techniques that enable them to construct any imaginable network in living bacteria and thus study the network dynamics from the single-cell level all the way to the level of small ecologies, in which bacteria interact with bacteriophages.

Current projects: Information processing and evolution of complex promoters; Single-cell biology of multi-drug resistance; Biology, ecology, and evolutionary dynamics of restriction-modification systems

Călin Guet

Career: since 2018 Professor, ISTA
2011–2018 Assistant Professor, ISTA
2009–2010 Postdoc, Harvard University, Cambridge, USA
2005–2008 Postdoc, The University of Chicago, USA
2004 PhD, Princeton University, USA

Hannezo Group

Physical Principles in Biological Systems

Cell Biology
Data Science
Physics

During embryo development, cells must "know" how to behave at the right place and at the right time. The Hannezo group applies methods from theoretical physics to understand how these robust choices occur.

In close collaboration with cell and developmental biologists, the Hannezo group is particularly particularly interested in design principles and processes of self-organization in biology at various scales and in close collaboration with cell and developmental biologists. Their methods include tools from solid and fluid mechanics, statistical physics as well as soft matter approaches. Examples of problems that the group is working on—at three different scales—include: (1) How do cytoskeletal elements, which generate forces within cells, self-organize to produce complex spatio-temporal patterns? (2) How do cells concomitantly acquire identities and shape a tissue during development? (3) How does complex tissue architecture derive from simple self-organizing principles, for instance during branching morphogenesis—in organs such as the kidneys, mammary glands, pancreas, and prostate—as a prototypical example.

Current projects: Stochastic branching in mammalian organs; Active fluids and cell cytoskeleton; Models of fate choices of stem cells during homeostasis and embryo development

Edouard Hannezo

Career: since 2022 Professor, ISTA
2017–2022 Assistant Professor, ISTA
2015–2017 Sir Henry Wellcome Postdoctoral Fellow, Gurdon Institute, Cambridge, UK
2015–2017 Junior Research Fellow, Trinity College, University of Cambridge, UK
2014 Postdoc, Institut Curie, Paris, France
2014 PhD, Institut Curie and Université Pierre et Marie Curie, Paris, France

Hausel Group
Geometry and its Interfaces

Mathematics

How can we understand spaces too large for traditional analysis? Combining ideas from representation theory and combinatorics, the Hausel group develops tools to study the topology of spaces arising from string and quantum field theory.
Suppose you have many particles, and consider the space of all the ways each particle can move between two points. Now, play the same game with more complicated objects, such as vector fields. The resulting spaces too large to analyze, can be simplified along structural symmetries. This gives rise to moduli spaces that are finite-dimensional, but non-compact defying traditional methods. The Hausel group studies the topology, geometry, and arithmetic of these moduli spaces. One question is the number of high-dimensional holes of the spaces. Using methods from representation theory and combinatorics, Hausel and his team are able to give results and conjectures that have previously been described by physicists and number theorists in other terms, thus connecting a variety of fields and ideas.

Current projects: Geometry, topology, and arithmetic of moduli spaces arising in supersymmetric quantum field theories; Representation theory of quivers, finite groups, Lie and Hecke algebras

Tamás Hausel

Career: since 2016 Professor, ISTA
2012–2016 Professor and Chair of Geometry, EPFL, Lausanne, Switzerland
2007–2012 Tutorial Fellow, Wadham College, Oxford, UK
2005–2012 Royal Society University Research Fellow and Lecturer, University of Oxford, UK
2002–2010 Assistant, Associate Professor, University of Texas, Austin, USA
1999–2002 Miller Research Fellow, University of California, Berkeley, USA
1998–1999 Member, Institute for Advanced Study, Princeton, USA
1998 PhD, Trinity College, University of Cambridge, UK

Heisenberg Group
Morphogenesis in Development

Cell Biology

The elaborate shapes of multicellular organisms—the orchid blossom, the lobster's claw—all start off from a simple bunch of cells. This transformation is a fundamental principle in cell and developmental biology and the focus of the Heisenberg group's work.
To gain insights into the critical processes in which the developing organism takes shape, the Heisenberg group focuses on gastrulation in zebrafish and ascidians, a process in which a seemingly unstructured blastula is transformed into an organized embryo. The group uses a transdisciplinary approach, employing a combination of genetic, cell biological, biochemical, and biophysical tools. Using these, the group addresses how the interplay between the physical processes driving cell and tissue morphogenesis and the gene regulatory pathways determining cell fate specification control gastrulation. Insights derived from this work may ultimately have implications for the study of wound healing and cancer biology, as immune and cancer cells share many morphogenetic properties of embryonic cells.

Current projects: Cell adhesion; Actomyosin contraction; Cell and tissue morphogenesis; Cell polarization and migration

Carl-Philipp Heisenberg

Career: since 2010 Professor, ISTA
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

Henzinger Group
Design and Analysis of Concurrent and Embedded Systems

Computer Science

Humans and computers are similar: while the interaction between two actors may be simple, additional actors complicate matters. The Henzinger group builds the mathematical foundations for designing complex hardware and software systems.
Software is one of the most complicated artifacts we create, making bugs unavoidable. The Henzinger group addresses the challenge of reducing software bugs in concurrent and embedded systems. The former consist of parallel processes that interact with one another. Because of the large number of possible interactions between parallel processes, concurrent software is particularly error-prone, and bugs may show up after years of flawless operation. Embedded systems interact with the physical world; an additional challenge for them is to react quickly to inputs. The group develops mathematical methods and computational tools for improving the reliability of concurrent and embedded software.

Current projects: Analysis and synthesis of concurrent software; Quantitative modeling and verification of reactive systems; Predictability and robustness for real-time and embedded systems; Formal methods for neural networks; Monitoring safety, security, and fairness of software

Thomas A. Henzinger

Career: since 2009 Professor, ISTA
2009–2022 President, ISTA
2004–2009 Professor, EPFL, Lausanne, Switzerland
1999–2000 Director, Max Planck Institute for Computer Science, Saarbrücken, Germany
1997–2004 Associate and Full 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

Higginbotham Group
Condensed Matter and Quantum Circuits

Physics

Quantum systems are fragile, and are constantly altered and disrupted by their environments. The Higginbotham group investigates electronic devices that are exceptions to this rule, aiming to understand the basic principles of their operations and develop future information-processing technology.
The Higginbotham group experimentally explores the boundaries between condensed-matter systems and quantum information processing. In practice, the group builds small electronic devices that combine superconductors, semiconductors, and mechanical oscillators. The central idea of their approach is that building rudimentary information-processing devices teaches us about the physics of these interesting systems along with advancing technology such as quantum computing.

Current projects: Circuit electrodynamics of p-wave superconductors; Electromechanics across a quantum phase transition; Stabilizing superconducting excitons in a hybrid circuit

Andrew Higginbotham

Career: since 2019 Assistant Professor, ISTA
2017–2019 Researcher, Microsoft Station Q Copenhagen, Denmark
2015–2017 Postdoc, JILA, USA
2015 PhD, Harvard University, Cambridge, USA

Hippenmeyer Group
Genetic Dissection of Cerebral Cortex Development

Cell Biology
Neuroscience

The human cerebral cortex, the seat of our cognitive abilities, is composed of an enormous number and diversity of neurons and glia cells. How the cortex arises from neural stem cells is an unsolved but fundamental question in neuroscience. In the pursuit of mechanistic insights, the Hippenmeyer group genetically dissects corticogenesis at unprecedented single cell resolution using the unique MADM (Mosaic Analysis with Double Markers) technology.
The Hippenmeyer group's current objectives are to establish a definitive quantitative and mechanistic model of cortical neural stem cell lineage progression, to dissect the cellular and molecular mechanisms generating cell-type diversity, and to determine the role of genomic imprinting, an epigenetic phenomenon, in cortex development. In a broader context, the group's research has the ultimate goal to advance the general understanding of brain function and why human brain development is so sensitive to disruption of particular signaling pathways in pathological neurodevelopmental diseases and psychiatric disorders.

Current projects: Determine neuronal lineages by clonal analysis; Mechanisms generating cell-type diversity; Probing genomic imprinting in cortex development

Simon Hippenmeyer

Career: since 2019 Professor, ISTA
2012–2019 Assistant Professor, ISTA
2011–2012 Research Associate, Stanford University, Palo Alto, USA
2006–2011 Postdoc, Stanford University, Palo Alto, USA
2004–2006 Postdoc, University of Basel and Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland
2004 PhD, University of Basel, Switzerland

Hof Group
Nonlinear Dynamics and Turbulence

Physics

Most fluid flows of practical interest are turbulent, yet our understanding of this phenomenon is limited. The Hof group seeks to gain insight into the nature of turbulence and the dynamics of complex fluids.
Flows in oceans, around vehicles, and through pipelines are all highly turbulent. Despite its ubiquity, insights into the nature of turbulence are very limited. To obtain a fundamental understanding of the origin and the principles underlying it, 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, enabling them 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. The group actively develops methods to control turbulent flow. In addition, the group investigates instabilities in fluids with more complex properties, such as dense suspensions of particles and polymer solutions.

Current projects: Revisiting the turbulence problem using statistical mechanics; Transition from laminar to turbulent flow; Dynamics of complex fluids; Control of fully turbulent flows; Cytoplasmic streaming; Instabilities in cardiovascular flows

Björn Hof

Career: since 2013 Professor, ISTA
2007–2013 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

Hosten Group
Quantum Sensing with Atoms and Light

Physics

The Hosten Group aims to develop innovative techniques to control quantum properties of atomic, optical, and mechanical systems with an eye on applications in the domain of quantum-enabled technologies and precision sensing, as well as in fundamental science.

The group's research focuses on developing new sensing methods that gainfully utilize quantum mechanical phenomena. By manipulating the collective properties of cold atomic ensembles in optical cavities, or mechanical systems coupled to optical cavities, they seek to investigate and gainfully utilize concepts of quantum entanglement, quantum measurement, and light-assisted atomic interactions to develop new sensing techniques. This includes force or acceleration sensing, or making ultra-precise clock. They do so while gaining insight into fundamental aspects of quantum mechanics. Using these sensors, the long-term goal is to explore challenging experimental questions such as the nature of dark matter and the interplay between quantum mechanics and gravity.

Current projects: Atom interferometry with spin squeezed atomic ensembles; Spin squeezing in a traveling wave optical cavity; Milligram scale opto-mechanical oscillators near the quantum regime; Hybrid systems of cold atoms and mechanical oscillators; Development of precision laser stabilization methods

Onur Hosten

Career: since 2018 Assistant Professor, ISTA
2015–2017 Research Associate, Stanford University, Palo Alto, USA
2010–2015 Postdoc, Stanford University, Palo Alto, USA
2010 PhD, University of Illinois at Urbana-Champaign, USA

Ibáñez Group
Functional Nanomaterials

Chemistry
Physics

Understanding structure property relationships as well as the development of materials for target applications is limited by our ability to control the nanostructure of solid state materials. One potential solution is through the use of nanoparticles, which can be used as precursors to create metamaterials.

The Ibáñez group develops novel functional nanomaterials using precisely designed nanocrystals as building blocks and investigates their properties as function of their finely tunable nanofeatures. In this way, the researchers are able to create a new generation of complex materials in which components and functionalities can be defined in a predictable way. Beyond fundamental studies in nanocrystal synthesis, surface chemistry and assembly, the group also aims to provide high-efficiency, cost-effective thermoelectric materials.

Current projects: Syntheses of novel metal and semiconductor nanocrystals; Unravelling of nanocrystal surface chemistry; Nanocrystals assembly, consolidation and sintering; Transport properties of nanocrystal-based solids; Bottom-up processed thermoelectric nanomaterials

Maria Ibáñez

Career: since 2022 VERBUND Professor for Energy Science, ISTA
since 2018 Assistant Professor, ISTA
2014–2018 Research Fellow, ETH Zurich, Switzerland
2013–2014 Research Fellow, Catalonia Institute of Energy Research (IREC), Barcelona, Spain
2013 Visiting Researcher, Northwestern University, Evanston, USA
2013 PhD, University of Barcelona, Spain

Jonas Group
Cellular Neuroscience

Neuroscience

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

Understanding the function of the brain is a major challenge in the 21st century. The human brain comprises approximately 100 billion neurons, which communicate through about 10,000 synapses per cell. Excitatory synapses use glutamate as a transmitter, whereas inhibitory synapses release Gamma-Aminobutyric acid (GABA). The group addresses two major questions: What are the biophysical signaling and plasticity mechanisms at glutamatergic and GABAergic synapses in the cortex? How do specific synaptic properties generate higher network functions? In their work, the group combines nanophysiology, presynaptic patch-clamp and multi-cell recording, two-photon Ca2+ imaging, optogenetics, functional anatomy, in vivo recording, and modeling. The main focus is on hippocampal mossy fiber synapses and output synapses of parvalbumin-expressing GABAergic interneurons.

Current projects: Biophysical mechanisms of synaptic plasticity at hippocampal mossy fiber synapses; Structural changes underlying transmission and plasticity at central synapses; Analysis of neuronal coding in vivo and in realistic network models

Peter Jonas

Career: since 2022 Magdalena Walz Professor for Life Sciences, ISTA
since 2010 Professor, ISTA
1995–2010 Professor of Physiology and Department Head, University of Freiburg, Germany
1994–1995 Associate Professor, Technical University of Munich, Germany
1990–1994 Postdoc, Max Planck Institute for Medical Research, Heidelberg, Germany
1988–1989 Postdoc, University of Giessen, Germany
1987 MD, University of Giessen, Germany

Jösch Group
Neuroethology

Neuroscience

The Jösch group is interested in understanding how the brain processes visual information at different stages and how the emerging computations influence behaviors. Using molecular and physiological approaches, they monitor brain activity during animal behavior to reveal the principles and motifs of neuronal computation.

Two different model organisms, the mouse and the fruit fly are used in parallel to gather a general, cross-phyla understanding of computational principles. Using a combination of awake-behaving imaging, electrophysiological and behavioral approaches in mice, the group studies the mechanisms used by the nervous system to send behaviorally relevant information from the eye to the brain, e.g. to detect a red apple in green foliage. With the fly, similar experimental approaches, combined with targeted genetic manipulations, are used to obtain a comprehensive understanding of the cellular basis of network computations, with an emphasis on course control.

Current projects: Intrinsic population dynamics of the superior colliculus; Role of electrical synapses in sensory transformations; Mechanisms of visual saliency and attention; State-dependent modulation of sensory information; Colliculi-thalamic visual computations; Large-scale retinal recordings; Superior colliculus and ASD—a midbrain perspective on disease progression

Maximilian Jösch

Career: since 2017 Assistant Professor, ISTA
2010–2016 Postdoc and Research Associate, Harvard University, Cambridge, USA
2009 Postdoc, Max Planck Institute of Neurobiology, Martinsried, Germany
2009 PhD, Max Planck Institute of Neurobiology, Martinsried, Germany and Ludwig Maximilian University, Munich, Germany

Kaloshin Group
Dynamical Systems, Celestial Mechanics, and Spectral Rigidity

Mathematics

"Can you hear the shape of a drum?" Essentially, this question (and title of a famous paper by M. Kac) asks if the sound of a drum determines its shape—an open question with deep mathematical roots. Vladimir Kaloshin and his group explore how deformations of a drum deform its sound, and if it is possible to change the shape of a drum without changing the sound.

In particular, they study the Laplace spectrum of convex, planar domains, and work to show that these eigenvalues determine such domains locally. Another focus of the Kaloshin group is stochastic behavior in our solar system. Between the orbits of Mars and Jupiter, there are nearly two million asteroids with diameters greater than one kilometer. Astonomers have observed that the distribution of these asteroids with respect to semi-major axis has gaps, known as Kirkwood gaps. The Kaloshin group seeks to achieve two goals: to develop a mathematical theory of stochastic behavior at these gaps and to explain the shape of the distribution of these gaps.

Current projects: Spectral rigidity for chaotic geodesic flows; Rigidity of planar convex domains; Rational caustics of domains with constant width

Vadim Kaloshin

Career: since 2021 Professor, ISTA
2007–2021 The Brin Chair in Mathematics, University of Maryland, College Park, USA
2008–2011 Distinguished Professor of Mathematics, The Pennsylvania State University, State College, USA
2002–2006 Associate Professor (tenure-track and tenured), California Institute of Technology, Pasadena, USA
2002–2004 Member of Institute of Advanced Study, Princeton University, USA
2001–2002 C.L.E. Moore Instructor, Massachusetts Institute of Technology, Cambridge, USA
2001 PhD Princeton University, USA

Katsaros Group
Nanoelectronics

Physics

It is impossible to picture modern life without the vast amount of microelectronic applications that surround us—a development made possible by the invention of the transistor in the 50s. At the time, this device measured a few centimeters. Now, the size of a transistor has shrunk to less than 14 nanometers and quantum physics comes into play. The Katsaros group investigates semiconductor nanodevices and studies quantum effects when these devices are cooled to -273.14°C.

The spin degree of freedom can be used to create a two-level system, a quantum bit or "qubit". While in classic computers, a bit can be in only one of two states, zero or one, in the quantum world, a qubit can be both zero and one at the same time. The group studies such qubits in germanium. In addition, the group investigates hybrid semiconductor-superconductor devices for seeking Majorana fermions. These have been suggested as building blocks for a topological quantum computer in which quantum information would be protected from environmental perturbations.

Current projects: Hybrid semiconductor-superconductor quantum devices; Hole spin orbit qubits in Ge quantum wells; High impedance circuit quantum electrodynamics with hole spins

Georgios Katsaros

Career: since 2022 Professor, ISTA
2016–2022 Assistant Professor, ISTA
2012–2016 Group Leader, Johannes Kepler University, Linz, Austria
2011–2012 Group Leader, Leibniz Institute for Solid State and Materials Research, Dresden, Germany
2006–2010 Postdoc, CEA, Grenoble, France
2006 PhD, Max Planck Institute for Solid State Research, Stuttgart, Germany

Kicheva Group
Tissue Growth and Developmental Pattern Formation

Cell Biology
Neuroscience

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.
Neural tube development is controlled by signaling molecules called morphogens. Morphogens determine what type of neuron a neural progenitor cell will become. They also control tissue growth by influencing the decisions of cells to divide or exit the cell cycle. The Kicheva group seeks to understand how morphogen signaling is controlled and interpreted by cells to determine cell fate and cell cycle progression. The group combines quantitative in vivo analysis of the mouse and chick neural tube with in vitro assays based on organoids, stem cell differentiation, and embryonic explants. They develop biophysical models to guide experimental design and the interpretation of data.

Current projects: Role of cell cycle dynamics in spinal cord patterning and morphogenesis; Morphogen control of tissue growth; Morphogen gradient formation; Interpretation of combined signaling inputs

Anna Kicheva

Career: since 2015 Assistant Professor, ISTA
2008–2015 Postdoc, National Institute for Medical Research, The Francis Crick Institute, UK
2008 PhD, University of Geneva, Switzerland, and Max Planck Institute of Cell Biology and Genetics, Dresden, Germany

Kokoris-Kogias Group
Secure, Private, and Decentralized Systems (SPiDerS)

Computer Science

In the last decades, computing enabled society to interconnect transcending physical limits. Our fast and interconnected digital world brings great challenges: our systems are left vulnerable to potential adversaries that exploit the security weaknesses unnoticed by developers while trying to cope with the ferocious demand for speed.
The SPiDerS group copes with the challenge of speed and trustworthiness by exploring decentralized trust technologies. It focuses on Byzantine fault tolerant systems and algorithms, including questions such as: How can the current financial ecosystem integrate scalable decentralized systems? How can we scavenge randomness from multiple semi-trustworthy players to run publicly verifiable lotteries or audit elections? The group's driving force stems from the technical challenges in existing systems, as well as the socio-technical barriers faced by conventional institutions. The SPiDerS group aspires to contribute to this rapidly evolving digital world by designing and building secure scalable decentralized systems with real-world impact.

Current projects: Performance and incentives for decentralized systems; Cryptographically secure distributed randomness generation; Theory and practice of scalable blockchains and interoperability; Decentralized private data management

Lefteris Kokoris-Kogias

Career: since 2021 Assistant Professor, ISTA
2020–2021 Research Scientist, Facebook Research/Novi, London, UK
2020 Research Scientist, Web3 Foundation, Zug, Switzerland
2019–2020 Postdoc, EPFL, Lausanne, Switzerland
2019 Visiting Scientist, VMware Research, Palo Alto, USA
2019 PhD, EPFL, Lausanne, Switzerland

Kolmogorov Group
Discrete Optimization

Computer Science

When we step out into the street, we automatically judge the distance and speed of cars. For computers, estimating the depth of objects in an image requires complex computations. A popular approach for tackling this problem is to use discrete optimization algorithms—the research focus of the Kolmogorov group.
The work of Vladimir Kolmogorov's group falls into three areas. The first is the development of efficient algorithms for inference in graphical models and combinatorial optimization problems. Some of the techniques developed in the group are well known in the community, such as the "Boykov-Kolmogorov" maximum flow algorithm, the "Blossom V" algorithm for computing a minimum cost perfect matching in a graph, and the "TRW-S" algorithm for MAP-MRF inference in graphical models. The second focus is the theoretical investigation of the complexity of discrete optimization, in particular using the framework of valued constraint satisfaction problems and their variants. Finally, the group has worked on applications of discrete optimization in computer vision, such as image segmentation.

Current projects: Inference in graphical models; Combinatorial optimization problems; Theory of discrete optimization

Vladimir Kolmogorov

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

Kondrashov Group
Evolutionary Genomics

Cell Biology
Evolution & Ecology

How did living organisms become the way we know them today? The Kondrashov group is focused on understanding the natural world in an evolutionary context, typically focusing on studying genetic information due the abundance of DNA and protein sequence data.
Kondrashov and his group do not restrict themselves to specific functions or phenotypes; instead, a staple feature of their research is a focus on how functions and phenotypes change over time. Therefore, their research is inherently interdisciplinary, grounded in classical evolutionary fields of population genetics and molecular evolution while drawing from other fields, such as cell and molecular biology, bioinformatics, and biophysics. Recently, the group has become increasingly interested in the experimental assay of fitness landscapes. Combining experiments, theory and computational biology, they query how changes in the genotype affect fitness or specific phenotypes. In the near future, they hope to expand their experimental capabilities in order to investigate a wider range of interesting phenotypes in a high-throughput manner.

Current projects: Empirical fitness landscapes; Protein evolution in the context of epistasis; Population genomics of the spoon-billed sandpiper

Fyodor Kondrashov

Career: since 2017 Professor, ISTA
since 2012 Scientific Director, School of Molecular and Theoretical Biology
2011–2017 ICREA Research Professor, Centre for Genomic Regulation, Barcelona, Spain
2008–2017 Junior Group Leader, Centre for Genomic Regulation, Barcelona, Spain
2008 PhD, University of California, San Diego, USA

Kwan Group
Combinatorics and Probability

Computer Science
Mathematics

Combinatorics is the area of mathematics concerned with finite structures and their properties. This subject is enormously diverse and has connections to many different areas of science. For example, objects of study include networks, sets of integers, error-correcting codes, voting systems, and arrangements of points in space.
Kwan's group studies a wide range of combinatorial questions, with a particular focus on the interplay between combinatorics and probability. On the one hand, it is suprisingly often possible to use techniques or intuition from probability theory to resolve seemingly non-probabilistic problems in combinatorics (this is the so-called probabilistic method, pioneered by Paul Erdős). On the other hand, combinatorial techniques are of fundamental importance in probability theory, and there are many fascinating questions to ask about random combinatorial structures and processes.

Current projects: Perfect matchings in random hypergraphs; Subgraph statistics in Ramsey graphs; Discrete random matrices; Partitioning problems in graphs and hypergraphs; Random designs; Transversal bases in matroids; Extremal problems on extension complexity of polytopes; Polynomial Littlewood-Offord problems; Ordered embedding problems

Matthew Kwan

Career: since 2021 Assistant Professor, ISTA
2018–2021 Szegő Assistant Professor, Stanford University, Palo Alto, USA
2018 DSc, ETH Zurich, Switzerland

Lampert Group
Machine Learning and Computer Vision

Computer Science
Data Science

The Lampert group performs research on how to make artificial intelligence methods more trustworthy. It investigates questions like: Can we understand not only what modern machine learning systems are doing, but also why? Can we give guarantees for their behavior? Can we build systems that learn and one day might become intelligent without sacrificing our rights to data protection and privacy?
Computers are becoming increasingly powerful at processing data, and they have learned to perform many tasks that were thought beyond their reach, such as making successful financial investments, diagnosing cancer from medical images, and even driving cars in traffic. So why don't we rely on them as financial advisors, oncologists, and chauffeurs? It is likely because we do not trust computers enough to let them operate important systems autonomously and outside of our control. Besides theoretical research, the group applies its results to applications in computer vision, such as image understanding, where the goal is to develop automatic systems that can analyze the contents of natural images.

Current projects: Trustworthy machine learning; Transfer and lifelong learning; Theory of deep learning

Christoph Lampert

Career: since 2015 Professor, ISTA
2010–2015 Assistant Professor, ISTA
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

Lemeshko Group
Theoretical Atomic, Molecular, and Optical Physics

Physics

"The whole is greater than the sum of its parts." Aristotle's saying holds true in many systems studied in quantum physics. The Lemeshko group investigates how macroscopic quantum phenomena emerge in ensembles of atoms and molecules.
Most polyatomic systems in physics, chemistry, and biology are strongly correlated—their complex behavior cannot be deduced from their individual components. Despite considerable effort, understanding strongly correlated, many-body systems still presents a formidable challenge. For instance, given a single atom of a certain kind, it is hard to predict the properties of the resulting bulk material. The Lemeshko group studies how many-particle quantum phenomena emerge in ensembles of atoms and molecules, and in doing so, answers answers questions such as: How many particles are sufficient for a given property to emerge? How does an external environment modify the properties of quantum systems? The group's theoretical efforts aim to explain experiments on cold molecules and ultra-cold quantum gases, as well as to predict novel phenomena.

Current projects: Understanding angular momentum properties of quantum many-particle systems; Studying open quantum systems and understanding how dissipation acts at the microscopic scale; Many-body physics of ultra-cold quantum gases; Developing techniques to manipulate atoms, molecules, and interactions between them with electromagnetic fields

Mikhail Lemeshko

Career: since 2019 Professor, ISTA
2014–2019 Assistant Professor, ISTA
2011–2014 ITAMP Postdoctoral Fellow, Harvard University, Cambridge, USA
2011 PhD, Fritz Haber Institute of the Max Planck Society, Berlin, Germany

Loose Group
Self-Organization of Protein Systems

Biochemistry
Cell Biology

How are nanometer-sized proteins able to perform complex cellular functions on a much larger scale? The research interest of the Loose group is to understand how proteins self-organize into dynamic spatiotemporal patterns using an in vitro reconstitution approach.
Dynamic protein assemblies play an important role for the organization of the cell in space and time. They emerge from a complex interplay between many different cellular components. A mechanistic understanding of the underlying processes, however, is often still not available. In the interdisciplinary Loose group, scientists combine protein biochemistry, biomimetic membrane systems, fluorescence microscopy, and image analysis to understand the emergent properties of biochemical networks that give rise to the living cell. The group aims to rebuild and understand two fundamental biological processes. First, bacterial cell division, with a focus on the cytokinetic machinery of *Escherichia coli*. Second, intracellular compartmentalization and how regulatory networks control the activity of small GTPases in space and time.

Current projects: Self-organization of the bacterial cell division machinery; Emergent properties of small GTPase networks

Martin Loose

Career: since 2021 Professor, ISTA
2015–2021 Assistant Professor, ISTA
2011–2014 Departmental Fellow, Harvard Medical School, Boston, USA
2010–2011 Postdoc, TU Dresden and Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany
2010 PhD, TU Dresden and Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany

Maas Group
Stochastic Analysis

Mathematics

Airplane turbulence and stock rate fluctuations are examples of highly irregular real-world phenomena subject to randomness, noise, or uncertainty. The Maas group develops new methods for the study of such random processes in science and engineering.
Random processes are often so irregular that existing mathematical methods are insufficient to describe them accurately. The Maas group combines ideas from probability theory, mathematical analysis, and geometry to gain insights into the complex behavior of these processes. Recent work was inspired by optimal transport, which deals with the optimal allocation of resources. The Maas group applies these techniques to diverse problems involving complex networks, chemical reaction systems, and quantum mechanics. Another focus is stochastic partial differential equations, which are commonly used to model high-dimensional random systems, such as bacteria colony growth and weather forecasting. The group develops robust mathematical methods to study these equations, which is expected to lead to new insights into the underlying models.

Current projects: Homogenization of discrete optimal transport; Curvature-dimension criteria for Markov processes; Gradient flow structures in dissipative quantum systems

Jan Maas

Career: since 2020 Professor, ISTA
2014–2020 Assistant Professor, ISTA
2009–2014 Postdoc, University of Bonn, Germany
2009 Postdoc, University of Warwick, UK
2009 PhD, Delft University of Technology, The Netherlands

Modic Group
Thermodynamics of Quantum Materials at the Microscale

Physics

From the stone tools of the Stone Age to the semiconductor devices of our modern information age, societies are defined by their materials. The next generation of materials, such as superconductors and spin liquids, will exploit the quantum mechanical nature of matter and drive future technologies, such as quantum computation.
The Modic group designs and builds experiments to enhance our understanding of quantum materials, and discover new ways to harness their power. They specialize in techniques that study the response of materials to strong magnetic fields, which can simplify complex material problems. Magnetic fields can be used to reduce the degrees of freedom that electrons can explore, or they can force materials to choose between a metallic or a superconducting state. These experiments provide guidance to construct theories of existing quantum materials and aid in the design of new technologies.

Current projects: Identifying new phases of matter in topological semimetals; Determining broken symmetries in high-temperature superconductors; Exploring the dynamics of spin liquid excitations

Kimberly Modic

Career: since 2020 Assistant Professor, ISTA
2016–2019 Postdoc, Physics of Microstructured Quantum Matter, Max Planck Institute for Chemical Physics of Solids, Dresden, Germany
2012–2016 Graduate Research Assistant, Pulsed Field Facility, National High Magnetic Field Laboratory, Los Alamos, USA
2015 PhD, University of Texas, Austin, USA

Mondelli Group
Data Science, Machine Learning, and Information Theory

Computer Science
Data Science

We are at the center of a revolution in information technology, with data being the most valuable commodity. Exploiting this exploding number of data sets requires addressing complex inference problems, and the Mondelli group works to develop mathematically principled solutions.
Inference problems arise in a variety of fields and applications; the Mondelli group focuses on two areas. In wireless communications, the goal is—given a transmission channel—to send information encoded as a message while optimizing certain metrics, such as complexity or bandwidth. In machine learning, the goal is to understand how many samples convey sufficient information to perform a certain task and to identify the optimal ways to utilize such samples. The Mondelli group is inspired by information theory, which leads to the investigation of fundamental questions. What is the minimal amount of information necessary to solve an assigned inference problem? Given this minimal amount of information, is it possible to design a low-complexity algorithm? What are the tradeoffs between the parameters at play?

Current projects: Fundamental limits and efficient algorithms for deep learning; Non-convex optimization in high-dimensions; Optimal code design for short block lengths

Marco Mondelli

Career: since 2019 Assistant Professor, ISTA
2017–2019 Postdoc, Stanford University, Palo Alto, USA
2018 Research Fellow, Simons Institute for the Theory of Computing, Berkeley, USA
2016 PhD, EPFL, Lausanne, Switzerland

Muller Group
Atmosphere and Ocean Dynamics

Data Science
Earth Science

What is the response of the hydrological cycle to global warming? What are the physical processes responsible for the organization of tropical clouds? And what is the contribution of internal waves to ocean mixing? These are just a few of the questions the Muller group is trying to answer.
The research activities of the Muller group lie in the fields of geophysical fluid dynamics and climate science. The team is particularly interested in processes that are too small in space and time to be explicitly resolved in the coarse-resolution Global Climate Models (GCMs) used for climate prediction. Important examples are internal waves in the ocean and clouds in the atmosphere. These small-scale processes need to be parametrized that is, modeled with simple equations in GCMs in order to improve current model projections of climate change. The group's overall goal is to improve our fundamental understanding of these small-scale processes of our climate, using theoretical and numerical tools, as well as in situ and satellite measurements.

Current projects: New theoretical perspectives on self-aggregation of clouds; Tropical energetics in a warming climate; Tropical cyclone formation and intensification; Ocean-atmosphere interactions

Caroline Muller

Career: since 2021 Assistant Professor, ISTA
2015–2021 CNRS researcher and Lecturer at Ecole Normale Superieure, Paris, France
2012–2015 CNRS researcher, Ecole Polytechnique, Paris, France
2010–2012 Research Scholar, Princeton University/GFDL, Princeton, USA
2008–2010 Postdoc, Massachusetts Institute of Technology, Cambridge, USA
2008 PhD, Courant Institute of Mathematical Sciences, New York University, New York, USA

Novarino Group
Genetic and Molecular Basis of Neuro-developmental Disorders

Neuroscience

The Novarino group studies the genes underlying inherited forms of neurodevelopmental disorders such as epilepsy, intellectual disability, and autism. Neurodevelopmental disorders affect millions of people and are often refractory to treatments. Her group employs various techniques to identify common pathophysiological mechanisms underlying this group of disorders.
Neurodevelopmental disorders are caused by mutations in a plethora of genes, whose role in the brain is mostly unknown. Identifying the molecular mechanisms underlying the genetic forms of seizure, autism syndromes, and intellectual disability may hold the key to developing therapeutic strategies for this group of conditions. The Novarino group studies the function of epilepsy-, intellectual disability-, and autism-causing genes at the system, cellular, and molecular levels. The goal is to provide a framework for the development of effective pharmacological therapies and the background for the identification of new pathological genetic variants.

Current projects: Molecular mechanisms underlying autism spectrum disorders; Modeling epileptic encephalopathies and autism spectrum disorders in human brain organoids; Role of the autism-associated gene CHD8 in cortical development; Role of branched amino acid-dependent pathways in neurodevelopmental disorders

Gaia Novarino

Career: since 2019 Professor, ISTA
2014–2019 Assistant Professor, ISTA
2010–2013 Postdoc, UCSD, La Jolla, USA
2006–2010 Postdoc, Center for Molecular Neurobiology, Hamburg, Germany and MDC/FMP, Berlin, Germany
2006 PhD, University La Sapienza, Rome, Italy

Palacci Group
Materiali Molli

Physics

Nature evolved to assemble complex arcitectures from simple builidng blocks that consume energy. Some examples are bacteria forming colonies, cell reshaping and muscles contracting. The general physical principles that lead to those remarkable and robust phenomena remain unveiled.
The Palacci group aims to unlock the organization mechanisms of such systems that consume energy. The group's research is experimental and curiosity-driven, primarily focused on systems at the colloidal scale—a microscopic scale, just one hundredth of the thickness of a human hair. The researchers investigate how to control materials by powering them from within and understand how to achieve order from noise. They are also exploring the design of modular microbots, carrying the physical and computational power to perform programmed dynamics without external control or feedback. Ultimately, the lab aims to emulate the fidelity and tunability of materials and organisms observed in nature using human-made or biomimetic materials.

Current projects: Emergent behavior in active matter; Materials powered from within; Smart materials; Metamachines, Machines made of machines

Jérémie Palacci

Career: since 2021 Assistant Professor ISTA
2021 Adjunct Professor, University of California, San Diego, USA
2020–2021 Associate Professor University of California, San Diego, USA
2015–2020 Assistant Professor, University of California, San Diego, USA
2010–2015 Postdoc, Center for Soft Matter Research, NYU, New York City, USA
2010 PhD, Université de Lyon, France

Pietrzak Group
Cryptography

Computer Science

The Cryptography group works on theoretical and cryptography—the science behind information security.
Sustainable cryptocurrencies. Bitcoin is the first decentralized digital currency, and the most successful cryptocurrency to date. To achieve security, Bitcoin requires huge amounts of computing power to be constantly wasted. The cryptography group develops more sustainable "Bitcoin like" block chains that use disk space instead of computation to achieve security.
Group Messaging. Messaging applications like Signal or WhatsApp are hugely popular and provide surprisingly strong security guarantees. The team works on group messaging, which aims at developing messaging protocols that efficiently scale to large groups without giving up any of the strong security and privacy guarantees of existing solutions.
Leakage-resilient cryptography. The team constructs schemes that are secure against "side-channel attacks", where an attacker exploits information leaked during computation from a cryptographic device like a smart card.

Current projects: Sustainable cryptocurrencies; Leakage-, Tamper-, and Trojan-resilient cryptography; Group messaging; Adaptive security

Krzysztof Pietrzak

Career: since 2016 Professor, ISTA
2011–2016 Assistant Professor, ISTA
2005–2011 Scientific Staff Member, Centrum Wiskunde & Informatica, Amsterdam, The Netherlands
2006 Postdoc, École Normale Supérieure, Paris, France
2005 PhD, ETH Zurich, Switzerland

Polshyn Group
Emergent Electronic Phenomena in 2D Materials

Physics

Graphene and other two-dimensional materials open exciting opportunities to realize electronic systems that show fascinating collective behaviors. Investigating electronic phenomena in these novel 2D materials could set the foundation for the next generation of electronic devices and quantum computation. The Polshyn group seeks to uncover new emergent electronic states in 2D materials and explore their unique properties.
The Polshyn group creates clean and exceptionally tunable 2D electronic systems by combining atomically-thin layers of graphene and other van der Waals materials in different ways and purposefully introducing misalignments. In the limit of strong interactions, electrons realize a number of correlated phases that include superconductivity, spin and valley ferromagnetism, and robust topological states. The Polshyn group uses ultra-low-temperature electronic transport measurements and other experimental techniques to probe the nature of emergent correlated states and search for the states with exotic topological properties.

Current projects: Chern insulators in graphene moiré systems; Probing the mechanisms of superconductivity in graphene heterostructures

Hryhoriy Polshyn

Career: since 2022 Assistant Professor, ISTA
2017–2022 Postdoc, University of California, Santa Barbara, USA
2017 PhD, University of Illinois Urbana-Champaign, USA

Robinson Group
Medical Genomics

Data Science
Evolution & Ecology

Common complex diseases such as type-2 diabetes, obesity, stroke, and cardiovascular disease are among the leading causes of mortality worldwide. Our limited understanding of how genetic variation and the environment affect health and disease makes it impossible to respond optimally, treat, and ultimately prevent symptoms.
The Robinson group develops statistical models and the computational tools required to implement these models for very large-scale human medical record data. The overall goal is to improve our understanding of how genetics and lifestyle shape our risk of disease. Why people develop first symptoms at different ages, or why the severity of symptoms varies, is not well understood.
The Robinson group works to better characterize the underlying pathways and relationships among diseases. Their goal is to improve our ability to predict not only an individual's overall risk of disease, but also when people are likely to become sick and how they might respond to different treatments.

Current projects: Statistical models for the genetic basis of common complex disease; Genetic basis of age of onset; Genetics of ageing; Maternal health; Genomic prediction for personalized health

Matthew Robinson

Career: since 2020 Assistant Professor, ISTA
2017–2020 Assistant Professor, University of Lausanne, Switzerland
2013–2017 Postdoc, University of Queensland, Brisbane, Australia
2009–2013 NERC Junior Research Fellow, University of Sheffield, UK
2008 PhD, University of Edinburgh, UK

Šarić Group
Computational Soft and Living Matter

Biochemistry
Cell Biology
Physics

How do lifeless molecules create living organisms? How can such processes fail, resulting in diseases? At the intersection of soft matter physics, molecular cell biology, and physical chemistry, the Šarić group studies the physical mechanisms behind non-equilibrium self-organization of biomolecules in healthy and diseased states.
Currently, the group is focused on investigating the physical principles of cellular reshaping and cell division across evolution, and on the formation of pathological protein aggregates in the context of neurodegenerative diseases.
The Šarić group develops computational models rooted in soft matter and statistical physics that are powerful in traversing scales and investigating collective phenomena. The group closely collaborates with experimental colleagues on a range of systems, from synthetic set-ups to living cells.

Current projects: Non-equilibrium protein assembly: from building blocks to biological machines; Evolution of trafficking: from archaea to eukaryotes; Rational design of cell-reshaping elements; Collagen assembly: from molecules to fibrils; Amyloid aggregation: Inhibition of self-replication and membrane-mediated control

Anđela Šarić

Career: since 2022 Assistant Professor, ISTA
2016–2022 Associate Professor, University College London, UK
2013–2016 HFSP Postdoctoral Fellow and Emmanuel College Junior Research Fellow, University of Cambridge, UK
2013 PhD, Columbia University, New York City, USA

Sazanov Group
Structural Biology of Membrane Protein Complexes

Biochemistry

Membrane proteins are responsible for many fundamental cellular processes, including the transport of ions and metabolites and energy conversion. They are also the target of about two thirds of modern drugs. However, membrane proteins, especially large complexes, are challenging to study and are thus under-represented in structural databases. The Sazanov group is interested in the structural biology of membrane proteins.
The research focus of the group has been on complex I of the respiratory chain, a huge (~1 MDa) enzyme central to cellular energy production. So far, they have determined the first atomic structures of complex I, from bacterial to the more elaborate mammalian version. The structures suggest a unique mechanism of proton translocation, which they study using X-ray crystallography and cryo-electron microscopy. The group also investigates other, related membrane protein complexes with the goal of explaining the molecular design of some of the most intricate biological machines.

Current projects: Mechanism of coupling between electron transfer and proton translocation in complex I; Structure and function of mitochondrial respiratory supercomplexes; Structure and function of other membrane protein complexes relevant to bioenergetics

Leonid Sazanov

Career: since 2015 Professor, ISTA
2000–2015 Group and Program Leader, MRC Mitochondrial Biology Unit, Cambridge, UK
1997–2000 Research Associate, MRC Laboratory of Molecular Biology, Cambridge, UK
1994–1997 Research Fellow, Imperial College, London, UK
1992–1994 Postdoc, University of Birmingham, UK
1990–1992 Postdoc, Belozersky Institute of Physico-chemical Biology, Moscow State University, Russia
1990 PhD, Moscow State University, Russia

Schanda Group
Biomolecular Mechanisms from Integrated NMR Spectroscopy

Biochemistry
Chemistry

Life is in motion. While one immediately recognizes the dynamics of living organisms on the macroscopic level, it is clear that ultimately it is the jiggling and wiggling of the atoms within molecules, and their interactions with each other, that allow life to unfold.
The Schanda group is particularly interested in understanding how proteins perform their tasks, and how their structural dynamics governs their functions. They study puzzling questions such as how proteins transport other proteins. By investigating their structure and how they move and interact, the team deciphers how cells are able to transport large and highly aggregation-prone polypeptides across the cell and ultimately refold them into their native environment. Furthermore, the group is interested in how motions around the active site of an enzyme control its function and how exactly the side chains and main chain of proteins move. Therefore, the Schanda group uses nuclear magnetic resonance (NMR) spectroscopy, which they further develop and combine with other biophysical, biochemical, in silico, and in vivo methods.

Current projects: Mitochondrial import machinery; Dynamics of enzymatic assemblies; New NMR methods to probe protein dynamics; Integration of NMR with various structural techniques for high-resolution structure determination

Paul Schanda

Career: since 2021 Professor, ISTA
2017–2020 Head of the NMR group, Institut de Biologie Structurale, Grenoble, France
2011–2021 Research team leader, Institut de Biologie Structurale, Grenoble, France
2008–2010 Postdoc, ETH Zurich, Switzerland
2007 PhD, Joseph Fourier University, Grenoble, France

Schur Group
Structural Biology of Cell Migration and Viral Infection

Biochemistry
Cell Biology

The Schur group aims to understand the structural and functional principles that control cell migration. In other projects, the group tries to elucidate evolutionary conserved assembly and maturation mechanisms in retroviruses. To this end they use and develop advanced cryo-electron microscopy and image processing methods to study the structure and function of protein complexes in situ.
In the field of cell migration, the group focuses on the actin cytoskeleton, the key player allowing cells to move. Here they aim to obtain an understanding of how cells dynamically and productively adapt the actin cytoskeleton to move in defined directions by varying the activity of a large number of regulatory proteins. In the field of virology, the group studies the structure of pleomorphic viruses by improving the versatility of cryo-EM data acquisition and the image processing methods. Specifically, the group is interested in the conservation and diversity of retroviral capsid assemblies, and why retroviruses developed a dependence on charge-compensatory molecules for assembly and maturation.

Current projects: Cellular structural biology of the actin cytoskeleton and cell migration; Structural conservation and diversity of retroviral capsid; Cryo-electron tomography and image processing method development

Florian Schur

Career: since 2017 Assistant Professor, ISTA
2016–2017 Postdoc, European Molecular Biology Laboratory, Heidelberg, Germany
2016 PhD, European Molecular Biology Laboratory, Heidelberg and University of Heidelberg, Germany

Seiringer Group
Mathematical Physics

Mathematics
Physics

The Seiringer group develops mathematical tools for the rigorous analysis of many-particle systems in quantum mechanics, with a special focus on exotic phenomena in quantum gases, like Bose-Einstein condensation and superfluidity.
A basic problem in statistical mechanics is to understand how the same equations on a microscopic level lead to a variety of very different manifestations on a macroscopic level. Due to the intrinsic mathematical complexity of this problem, one typically resorts to perturbation theory or other uncontrolled approximations, whose justification remains open. The challenge is thus to derive non-perturbative results and obtain the precise conditions under which various approximations can or cannot be justified. For this, new mathematical techniques and methods are needed; these stand to increase our understanding of physical systems. Concrete problems under investigation include the spin-wave approximation in magnetism, the validity of the Bogoliubov approximation in the description of dilute Bose gases, and the behavior of polaron systems at strong coupling.

Current projects: Polaron models at strong coupling; The Heisenberg ferromagnet at low temperature and the spin-wave approximation; Validity of the Bogoliubov approximation

Robert Seiringer

Career: since 2013 Professor, ISTA
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

Serbyn Group
Condensed Matter Theory and Quantum Dynamics

Physics

How do isolated quantum systems behave when prepared in a highly non-equilibrium state? How can such quantum systems avoid ubiquitous relaxation to a thermal equilibrium? How can we gain novel insights into properties of quantum matter using modern non-equilibrium probes? These and other open questions in the field of quantum non-equilibrium matter are the focus of the Serbyn group.
The majority of isolated quantum systems thermalize, that is, reach thermal equilibrium when starting from non-equilibrium states. One research focus of the Serbyn group is to understand mechanisms of thermalization breakdown. Many-body localized systems present one generic example of thermalization breakdown due to the presence of strong disorder. The group studies the properties of many-body localized phase and phase transition into the thermalizing phase. In addition, systems with quantum many-body scars avoid thermal equilibrium, however, only when prepared in specific initial condition. The Serbyn group is actively studying the properties of quantum many-body scars and their potential applications.

Current projects: Many-body localization; Quantum ergodicity breaking; Non-equilibrium probes of solids; Multilayer graphene

Maksym Serbyn

Career: since 2022 Professor, ISTA
2017–2022 Assistant Professor, ISTA
2014–2017 Gordon and Betty Moore Postdoctoral Fellow, University of California, Berkeley, USA
2014 PhD, Massachusetts Institute of Technology, Cambridge, USA

Shigemoto Group
Molecular Neuroscience

Neuroscience

Information transmission, the formation of memory, and plasticity are all controlled by various molecules at work in the brain. By 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 of the connecting nerve cell, is the primary process 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 information processing. 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.

Current projects: New chemical labeling methods for high resolution EM visualization of single molecules; Ultrastructural localization and distribution of receptors and ion channels in the brain; Mechanisms of long-term memory formation; Left-right asymmetry of hippocampal circuitry

Ryuichi Shigemoto

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

Siegert Group
Neuroimmunology in Health and Disease

Cell Biology
Neuroscience

Identifying brain function has primarily concentrated on how environmental signals are encoded within a complex neuronal network. However, the impact of the immune system was mostly overlooked. The Siegert group focuses on how neurons and microglia interact with each other and how malfunctions within this relationship affect neuronal circuit formation and function in health and disease.
Microglia are the CNS-resident macrophages and continually sense their neuronal environment. They switch between functional states that may promote or counteract the removal of circuit elements. So far, it is not known how microglia decide when to alter circuit elements. However, this information is critical since misinformed microglia can disconnect circuits leading to a disease outcome. Highly reactive microglia are for example a feature of various neurodegenerative diseases such as retinal degeneration and Alzheimer's. The Siegert group addresses microglia function across the cortex as well as in the mammalian retina, which consists of morphologically well-defined cell types that are precisely mapped in their connection and functional properties.

Current projects: Defining and manipulating microglial reactivity; Impact of microglia on neuronal function

Sandra Siegert

Career: since 2015 Assistant Professor, ISTA
2011–2015 Postdoctoral Associate, Massachusetts Institute of Technology, Cambridge, USA
2010 PhD, Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland

Sixt Group
Morphodynamics of Immune Cells

Cell Biology

Immune cells zip through our bodies at high speeds to fight off infections and diseases. The Sixt group works at the interface of cell biology and immunology to investigate how cells migrate and communicate in tissues.
Most cells in our bodies are stationary, forming solid tissues and encapsulated organs. One exception is leukocytes, the cells mediating innate and adaptive immune responses to infections. Leukocytes migrate with extraordinary speed and are the Sixt group's favorite model system. The group seeks to identify basic mechanistic principles of how cells change shape, move the cell body, and interact with other cells to coordinate their behavior. These principles are important for processes such as embryonic development, regeneration and cancer cell dissemination. The group also investigates how cells navigate along guidance cues, specifically how they orient their polarity axis in response to chemotactic gradients. In their work, they combine genetics, biochemistry, pharmacology, micro-engineering, surface chemistry, advanced imaging and theoretical approaches.

Current projects: Environmental control of leukocyte migration; Cellular force generation and transduction; Interpretation of chemo-attractive gradients

Michael Sixt

Career: since 2013 Professor, ISTA
2010–2013 Assistant Professor, ISTA
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 Approbation in human medicine

Sweeney Group
Evolution, Development, and Function of Motor Circuits

Cell Biology
Evolution & Ecology
Neuroscience

Movement is fundamental to nearly every animal behavior: to escape predators, to eat and breathe, animals must move. The Sweeney group aims to define the molecular, cellular, and neural circuit components that underlie differences in motor behavior, and to explore how such differences arise during an organism's development.
The group uses the *Xenopus* frog to address these fundamental questions. The frog undergoes metamorphosis, transitioning from a swimming tadpole to a walking frog during development. The Sweeney group explores this transition and categorizes, compares, and manipulates frog neurons at each stage. This allows the scientists to map variations in cellular properties and neural circuit structure onto differences in motor behavior. Knowledge about such cell-circuit-behavior relationships in the frog will provide a basis for comparing motor circuits between tetrapods, understanding how motor circuits evolved from swimming to walking during evolution, and pinpointing how motor circuits break down in movement disorders.

Current projects: Single cell sequencing of tadpole versus frog neurons; Viral tracing of neural circuits for swimming and walking; Multiphoton imaging of calcium dynamics over metamorphosis

Lora Sweeney

Career: since 2020, Assistant Professor, ISTA
2011–2020 Postdoc, Salk Institute for Biological Studies, San Diego, USA
2011 PhD, Stanford University, Palo Alto, USA

Tkačik Group
Information Processing in Biological Systems

Cell Biology
Data Science
Evolution & Ecology
Neuroscience
Physics

How do networks built out of biological components—neurons, signaling molecules, genes, or even cooperating organisms—process information? In contrast to engineered systems, biological networks operate under strong constraints due to noise, limited energy, or specificity, yet still perform their functions reliably. The Tkačik group uses biophysics and information theory to understand the principles and mechanisms behind this remarkable phenomenon.
How can cells in a multicellular organism reproducibly decide what tissue they become? How do neurons in the retina cooperate to best encode visual information as neural spikes? How does the physics at the microscopic scale, which dictates how individual regulatory molecules interact with each other, constrain the kinds of regulatory networks observed in real organisms, and how can such networks evolve? With the goal of developing theoretical ideas about biological network function and connecting these to high-precision data, the Tkačik group seeks to answer these and other questions through data-driven and theoretical projects.

Current projects: Visual encoding in the brain; Genetic regulation during early embryogenesis; Collective dynamics; Evolution of gene regulation

Gašper Tkačik

Career: since 2017 Professor, ISTA
2011–2016 Assistant Professor, ISTA
2008–2010 Postdoc, University of Pennsylvania, Philadelphia, USA
2007 Postdoc, Princeton University, USA
2007 PhD, Princeton University, USA

Vicoso Group
Sex-Chromosome Biology and Evolution

Data Science
Evolution & Ecology

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, the researchers can address a variety of standing questions, such as: Why do some Y chromosomes degenerate while others 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?

Current projects: Sex chromosome turnover and conservation; Dosage compensation in female-heterogametic species; Gene expression evolution in sexual and asexual species

Beatriz Vicoso

Career: since 2020 Professor, ISTA
2015–2020 Assistant Professor, ISTA
2009–2014 Postdoc, University of California, Berkeley, USA
2010 PhD, University of Edinburgh, Scotland, UK

Vogels Group
Computational Neuroscience and Neurotheory

Data Science
Neuroscience

The Vogels group seeks to build models of neurons and neuronal networks that distill and re-articulate the current knowledge of how nervous systems compute at a mechanistic level. Of particular interest is the neuronal interplay of excitatory and inhibitory activity in the cortex and how these dynamics can form reliable sensory perceptions, stable memories, and motor outputs.
Work in the Vogels lab is divided into three main areas: plasticity, network dynamics and computation, and single-neuron biophysics. In the first, the group uses mechanistic models of synaptic plasticity to find the rules governing how the brain updates its synaptic connections to learn and adapt to a changing world. In the second, they seek to understand how neuronal networks process and transform sensory inputs, store and manipulate memories, and send motor outputs. In the third, they build detailed biophysical models of single neurons to understand the complex input-output relationships at the level of single neurons and their dendritic branches.

Current projects: Machine learning-guided searches for synaptic plasticity in cortical neuron models; Spontaneous activity as a homeostatic controller of neuronal metabolism; Interdependent synaptic plasticity between excitatory and inhibitory neurons; Context-dependent memory switching

Tim Vogels

Career: since 2020 Professor, ISTA
2013 – 2020 Hayward Junior Research Fellow, Sir Henry Dale Wellcome Trust & Royal Society Research Fellow, Fellow of St. Peter's College, and Associate Professor, University of Oxford, UK
2010 – 2013 Marie Curie Postdoctoral Fellow, EPFL, Lausanne, Switzerland
2007 – 2010 Patterson Trust Postdoctoral Fellow, Columbia University, New York City, USA
2007 PhD, Brandeis University, Waltham, USA

Wagner Group
Discrete and Computational Geometry and Topology

Computer Science
Mathematics

How and when can a geometric shape be embedded in n-dimensional space without self-intersections? The Wagner group's research program focuses on combinatorial and computational geometry and topology.
A simplicial complex is a description of how to represent a geometric shape by joining points, edges, triangles, and their n-dimensional counterparts in a "nice" way. Simplicial complexes are a natural way to represent shapes for computation and algorithm design, and the Wagner group explores both their topological properties as well as what can be proved about their combinatorics e.g., bounds on the number of simplices given particular constraints. They take classical topological questions and consider them from a combinatorial point of view, and conversely, they use techniques and ideas from topology to approach questions in combinatorics. They are moreover interested in the computational aspects of these problems, such as question of decidability and complexity like: Does an algorithm exist? And if so, what are the costs in terms of time or space?

Current projects: Embeddings of simplicial complexes; Topological Tverberg-type problems and multiple self-intersections of maps; Discrete isoperimetric inequalities and higher-dimensional expanders

Uli Wagner

Career: since 2018 Professor, ISTA
2013–2018 Assistant Professor, ISTA
2012–2013 SNSF Research Assistant Professor, EPFL, Lausanne, Switzerland
2006–2012 Postdoc and Senior Research Associate, ETH Zurich, Switzerland
2004–2006 Postdoc, Einstein Institute of Mathematics, The Hebrew University of Jerusalem, Israel
2004 Postdoc, Univerzita Karlova, Prague, Czech Republic
2003 Postdoc, Mathematical Sciences Research Institute, Berkeley, USA
2004 PhD, ETH Zurich, Switzerland

Waitukaitis Group
Soft and Complex Materials

Physics

Scott Waitukaitis leads an experimental soft matter physics lab. The group addresses a variety of topics from the nanoscale to the macroscale, using experimental techniques ranging from atomic force microscopy to high-speed imaging.
One focus is tribocharging—the exchange of electrical charge between materials during contact. Although known to occur since ancient Greece, the underlying mechanism remains poorly understood. Recent results suggest adsorbed water layers could play a critical role, donating hydroxide ions through minute "liquid bridges". An alternative hypothesis is that mechanical activity weakens chemical bonds, leading to heterolytic cleavage and the release/transfer of charged moieties. Using atomic force microscopy to characterize charged surfaces at the nanoscale and a variety of other techniques to measure charge exchange, a major goal is to test these hypotheses. The group also considers the non-Newtonian dynamics that arise when colloidal-sized solid particles are suspended in liquids, and the interaction of soft, vaporizeable solids with superheated substrates.

Current projects: Mesoscale charging statistics with acoustic levitation; Macro-charging of oxide nanolayers on soft polymer substrates; In situ charge adsorption/desorption events with optical tweezers; Active Quincke rollers for flow control; Elastic and charged Leidenfrost effects

Scott Waitukaitis

Career: since 2019 Assistant Professor, ISTA
2016–2018 NWO Veni Recipient and Postdoc, AMOLF, Amsterdam, The Netherlands
2013–2016 Postdoc, Leiden University, The Netherlands
2007–2013 PhD, University of Chicago, USA

Wojtan Group
Computer Graphics and Physics Simulation

Computer Science
Data Science

Computer simulations of natural phenomena are indispensable for modern scientific discoveries, modern engineering, and the digital arts. The Wojtan group uses techniques from physics, geometry, and computer science to create efficient simulations and detailed computer animations.
Natural phenomena like flowing fluids and shattering solids are both beautifully chaotic and overwhelmingly complex. This complexity makes them extremely difficult to compute without the aid of a supercomputer. The Wojtan group overcomes this complexity by combining laws of motion from physics, geometric theories from mathematics and algorithmic optimizations from computer science to efficiently compute highly complicated natural phenomena on consumer-grade computing hardware. Their research achieves some of the world's fastest and most detailed simulations through a deeper understanding of the underlying mathematical models and inventing novel computational techniques.

Current projects: Efficient simulation of fluid dynamics; Geometry processing of time-dependent foam structures; Numerical homogenization of knitted and woven materials; Numerical and geometric algorithms for solving partial differential equations; Algorithms for re-using simulation data; Computational physics applied to motion pictures, video games, and virtual reality

Chris Wojtan

Career: since 2015 Professor, ISTA
2011–2014 Assistant Professor, ISTA
2010 PhD, Georgia Institute of Technology, Atlanta, USA

Zilberman Group
Epigenetics and Chromatin

Cell Biology
Evolution & Ecology

Most of the information that passes across generations is encoded in the DNA sequence. However, there is increasing appreciation that cells and organisms also receive inherited information through other mediums, known collectively as epigenetic. The Zilberman group studies cytosine DNA methylation, a key epigenetic mechanism in plant and animal cells.
Cytosine methylation can carry epigenetic information because it is precisely copied when the DNA is replicated. Methylation regulates gene expression, and accurate reproduction of DNA methylation patterns during cell division is therefore essential for plant and animal development, efficient agriculture, and human health. The enzymes that maintain DNA methylation must work within chromatin, and in particular content with nucleosomes—tight complexes of DNA and histone proteins. The Zilberman group combines genetic, genomic, biochemical, and evolutionary approaches to understand the maintenance and function of DNA methylation within chromatin using the flowering plant *Arabidopsis thaliana* as the primary model.

Current projects: Regulation of DNA methylation patterns by chromatin remodelers and linker histones; Influence of DNA methylation on nucleosome properties; Mathematical modeling of DNA methylation inheritance; Evolution of eukaryotic DNA methylation pathways; Epigenetic inheritance as a mechanism of phenotypic diversification in natural populations

Daniel Zilberman

Career: since 2021 Professor, ISTA
2017–2021 Group Leader, John Innes Centre, Norwich, UK
2007–2017 Associate Professor, University of California, Berkeley, USA
2004–2007 Postdoc, Fred Hutchinson Cancer Research Center, Seattle, USA
2004 PhD, University of California, Los Angeles, USA

Staff Scientists

Staff scientists are fully trained researchers who work closely with various research groups on campus. They provide domain-specific skills, expertise, and experience not usually present within research groups and assist in the development of the Scientific Service Units (SSUs). They provide advanced training in data analysis, sample preparation, imaging, and much more.

Staff scientist positions are not unique to ISTA, but in contrast to others, the Institute's staff scientists are independent of a particular research group, and thus are free and encouraged to work with any research group or SSU. Their support and collaboration is critical to the success of numerous projects at ISTA, because of their ability to devise innovative solutions to research questions. In addition, their continued presence prevents the loss of knowledge as other scientists leave the Institute and sustains the stability of institutional structures.

Similar to the faculty professors, staff scientists receive a fixed-length contract at the beginning of their employment and are evaluated after five years. If successful, they receive permanent contracts. The Institute currently employs eight staff scientists of diverse backgrounds who share their time in collaborations with research groups, assisting SSUs, and advancing their own projects.

Satish Arcot Jayaram
Preclinical Facility

Satish Arcot Jayaram provides comprehensive support to research groups who would like to apply genome engineering technology to generate transgenic rodents. He collaborates with laboratories who perform comparative genomics, especially for genes with broader biological functions.
A gene usually encodes a protein, which carries out a function in a cell at a specific location; this in turn contributes to either a single process or multiple biological processes. Most of the components in a biological process are conserved across evolution. Hence, researchers use animals, mostly rodents, as genetic models to understand mammalian gene function. By manipulating their genome, scientists try to understand complex biological processes. Representing the transgenic unit of the Preclinical Facility, Jayaram offers advice to researchers and carries out the entire process from design to identification of founder animals with modified genomes. The unit aims to keep up with the latest genome engineering technologies and to aid ISTA researchers with the best transgenic models for their research.

Current projects: Generating floxed alleles to study neurodevelopmental disorders (Novarino group); Knock-in mice with epitope tags for in-vivo labeling experiments (Shigemoto group); Generation of floxed alleles to study comparative genomics (De Bono group); Tissue-specific and temporally expression of mutant genes with FLEx mice and transgenic rats (Hippenmeyer group); knock-in mouse lines to study expression patterns (Jonas and Sixt groups)

Satish Arcot Jayaram

Career: since 2020 Staff Scientist, ISTA
2019–2020 Senior Scientific Officer, CRUK-MI, University of Manchester, UK
2015–2019 Postdoc, University of Oxford, UK
2010–2014 Postdoc, MRC Laboratory of Molecular Biology, Cambridge, UK
2010 PhD, Stockholm University, Sweden

Dániel Balázs
Lab Support Facility

The properties of materials are encoded in their structures, with the relevant length scales ranging from sub-nanometers to centimeters. Each length scale, each material system, each studied detail requires a different investigative approach. When faced with such challenges, ISTA researchers can consult Dániel Balázs, who helps them find the way to determine the desired information.
Balázs helps design experiments using the two X-ray characterization instruments on campus, and analyzes complex datasets on a broad range of materials, mostly inorganic. His expertise in characterizing disorder in otherwise ordered systems both qualitatively and quantitatively is applied to thermoelectric materials by the Ibáñez group and to battery research by the Freunberger group. His personal research interest is self-assembly in the grey area between molecular and bulk systems, such as the interactions of organic-inorganic clusters consisting of hundreds to thousands of atoms.

Current projects: Structural evolution and phase diagram of lithium polysulfides for next generation batteries (Freunberger group); In operando tracking the degradation of transition metal oxide cathodes (Freunberger group); Phase diagram, processing-related structural changes and structure-property relationships in a broad range of thermoelectric ceramics (Ibáñez group); Formation of 3D superlattices from nanostructured colloid building blocks (Ibáñez group)

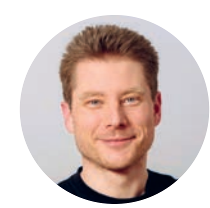
Dániel Balázs

Career: since 2022 Staff Scientist, ISTA
2020–2022 Postdoc, ISTA
2018–2020 Postdoc, Cornell University, New York, USA
2018 PhD, University of Groningen, The Netherlands

Robert Hauschild
Imaging & Optics Facility

Robert Hauschild brings expertise in imaging, optical engineering, automation, and image analysis to ISTA. Affiliated with the Imaging and Optics Facility, he collaborates with scientists from different fields to develop innovative solutions for unique microscopy problems, including designing and building new equipment and software.
State-of-the-art microscopy not only involves the physics of imaging, it also incorporates automation, system control, and an entire image analysis pipeline. Which methods are best suited to a particular project is not always clear, and Hauschild provides ISTA scientists with valuable expertise in cutting-edge microscopy techniques: From the evaluation of commercially available equipment to custom modifications of hardware and software. An illustrative example of his work is a UV ablation system that has been used by many ISTA researchers and several academic visitors. Originally devised to study stress in tissue, it has since found application in a diverse array of assays, from wound healing to cell migration.

Current projects: Development of tools that help other researches utilize their microscopes to the fullest extent; Hardware for sample manipulation and environmental control, and automation software; Accessories and protocols to evaluate and maintain microscope performance; Image analysis and quantification of a wide range of systems from morphodynamics of immune cells, bacteria in mother machines, to the structure of lymph nodes



Robert Hauschild

Career: since 2021 Senior Staff Scientist, ISTA
2010–2021 Staff Scientist, ISTA
2007–2010 Engineer for laser scanning, light sheet, and two photon microscopes, Zeiss MicroImaging, Jena, Germany
2006–2007 Postdoc, Karlsruhe Institute of Technology, Germany
2006 PhD, Karlsruhe Institute of Technology, Germany

Walter Kaufmann
Electron Microscopy Facility

When scientists at ISTA are interested in applying advanced electron microscopy to their research in the life sciences, but are unsure how to go about it, they talk to Walter Kaufmann, senior staff scientist with the Electron Microscopy (EM) Facility on campus.
Kaufmann's focus is on the ultrastructural analysis of biological tissues and cells and the high-resolution localization of trans-membrane proteins. He investigates their cell-type specific expression, subcellular localization and association with micro- and nano-domains, applies state-of-the-art electron microscopy techniques, and develops new sample preparation procedures. Key methodologies performed are pre- and post-embedding immunogold EM, 3D serial section TEM, electron tomography (3D STEM), high-pressure freezing plus freeze-substitution, platinum-replica EM, and freeze-fracture replica labeling. His main current collaborations are within the fields of structural and molecular neurosciences, immune cell morphodynamics, cell biology of plants, and morphogenesis in development.

Current projects: 3D-visualization of planta clathrin-coated vesicles and the localization of endocytosis related proteins at ultrastructural resolution (Friml group); Regulatory mechanisms in megakaryocyte and platelet homeostasis in a CLEM approach (Sixt group); Ultrastructural localization of brain proteins associated with extracellular vesicles (Novarino group)

Walter Kaufmann

Career: since 2022 Senior Staff Scientist, ISTA
2013–2022 Staff Scientist, ISTA
2013 Habilitation in Neurosciences, Innsbruck Medical University, Austria
2004–2013 Research Scientist, Innsbruck Medical University, Austria
2002–2004 Postdoc, Centre for Molecular Biology and Neuroscience, Oslo, Norway
1997–2002 Postdoc, Innsbruck Medical University, Austria
1997 PhD, Leopold Franzens University Innsbruck, Austria

Jack Merrin
Nanofabrication Facility

Microfluidics involves the experimental manipulation of fluids and objects, such as live cells, at small length scales. Nanofabrication Facility staff scientist Jack Merrin develops novel and innovative systems to study diverse biophysical phenomena together with various groups at ISTA.
Transparent microfluidic devices are ideal for analyzing single cells, as well as cell culture and micro-environmental control, all of which can be done while performing microscopy. Merrin and the Friml group used a set-up allowing rapid change of the chemical environment around plant roots revealing a rapid growth response to auxin hormone important for gravitropism. Merrin and the Sixt group found that dendritic cells move through obstacles along the path of least resistance to protect the nucleus and can also move by pushing off irregularly shaped walls in the absence of surface adhesion.

Current projects: Microfluidic sorting of *C. elegans* (de Bono group); Cell patterning with stencils (Kicheva group); Spatiotemporal control of A. thaliana root growth (Friml group); Single-cell lineage analysis of *E. coli* with mother machines (Guet group); Microfluidic measurement of mutation rates (Hof group); Optically transparent microwells for cell-cell contact developmental studies (Heisenberg group); Micropatterned chrome grids on glass for in vitro membrane biochemistry (Loose group); Spatiotemporal control of chemotactic gradients for immune cells, cancer cell migration in post arrays, and cell migration through obstacles and mazes (Sixt group)

Jack Merrin

Career: since 2013 Staff Scientist, ISTA
2012 Postdoc, Memorial Sloan Kettering Cancer Center, New York, USA
2009–2011 Postdoc, The Rockefeller University, New York, USA
2007–2009 Postdoc, Joseph Fourier University, Grenoble, France
2006 PhD, Princeton University, New Jersey, USA

Mary Muhia
Preclinical Facility

Mary Muhia collaborates with various groups at ISTA to offer expertise in designing and implementing behavioral studies in animal models. She develops and establishes rodent paradigms at the Preclinical Facility to evaluate behavioral functions, including motivation and emotion, cognition, and sensory processes.
Research in behavioral neuroscience has improved our understanding of various human conditions and led to the availability of tools necessary to understand the neural basis of cognitive processes such as learning and memory. Muhia works with the Novarino group, which studies the genetic and molecular basis of human disorders such as autism, epilepsy, and intellectual disability using mouse models. She collaborates with researchers interested in combining behavioral paradigms with optical techniques. With the Shigemoto group, she is working to establish in vivo calcium imaging to understand the temporal dynamics by which neuronal ensembles mediate the retrieval of fear memories. A project with the Jonas group involves optogenetic manipulation to quantify the specific ensemble of hippocampal neurons necessary for fear expression.

Current projects: Behavioral evaluation of mouse models of autism, epilepsy, and intellectual disability (Novarino group); In vivo calcium imaging coupled with optogenetic manipulation to link neural circuit activity and memory formation (Shigemoto and Novarino groups); In vivo optogenetic reactivation to map quantitatively hippocampal neuron populations sufficient for recall of specific memories (Jonas group)

Mary Muhia

Career: since 2021 Staff Scientist, ISTA
2011–2020 Postdoc, Center for Molecular Neurobiology, Hamburg, Germany
2010–2011 Postdoc, ETH Zurich, Switzerland
2010 PhD, ETH Zurich, Switzerland

Christoph Sommer
Imaging & Optics Facility

Christoph Sommer is an expert in image analysis, especially in creating software to automate image analysis. His work focuses on the interface of computer science and biology, where he develops and establishes new technology for computer-aided image and video analyses.
Sommer's work involves a variety of groups and experimental systems. With the Novarino and Cremer groups, he established multi-animal behavioral analysis to quantify complex social behavior and interactions of mice and ants. With the Danzl and Friml groups, he showed that super-resolution imaging of expanded plant tissue enables novel biological assays far beyond the diffraction limit. With the Loose group, he established a novel method for quantifying filament dynamics in in vitro experiments of treadmilling cytoskeletal proteins, which aids in the better understanding of protein (self-)organization. A tadpole project with the Sweeney group is also underway—involving deep learning-based body part detection and tracking. It will enable the study of many aspects in neural locomotor networks of developing *Xenopus* frogs.

Current projects: Expansion microscopy in plants (Friml and Danzl groups); Cell type identification (Novarino group); Mouse behavioral analysis (Novarino group); Image Enhancement (Danzl and Heisenberg group); Treadmilling filaments (Loose group); Tadpole locomotion analysis (Sweeney group); EM vesicle segmentation (Friml and Novarino group)

Christoph Sommer

Career: since 2017 Staff Scientist, ISTA
2013–2017 Staff Scientist, Institute of Molecular Biology Austria (IMBA), Vienna, Austria
2011–2013 Postdoc, ETH Zurich, Switzerland
2010–2011 Postdoc, Heidelberg Collaboratory for Image Processing (HCI), Germany
2010 PhD, University of Heidelberg, Germany

Jake Yeung
Scientific Computing

With the rapid developments in single-cell sequencing technologies, it is now possible to interrogate the epigenomes and transcriptomes of thousands of cells. A growing need is the development of new statistical and machine learning methods to uncover gene regulatory principles from highly multimodal single-cell genomics data.
Scientists at ISTA can discuss with Jake Yeung about how to design their sequencing experiments to optimize for inference and get a global view of the unique analysis challenges to answer their biological questions. He focuses on the design and analysis of single-cell sequencing experiments to uncover gene regulatory principles underlying cellular decision-making. Therefore, he uses widely available single-cell assays (e.g., scATAC-seq and scRNA-seq) as well as more bespoke assays (e.g., scChIC-seq to target histone modifications) to sample large numbers of individual cells across multiple regulatory layers. He also works with computational groups to connect models to single-cell sequencing data.

Current projects: Early development of *P. Mammillata* (Heisenberg group); Spatially-resolved transcriptomics (Sweeney group); Multi-omics in cortex (Siegert group)

Jake Yeung

Career: since 2021 Staff Scientist, ISTA
2021 Machine Learning Team Leader, Wellcome Sanger Institute, Cambridge, UK
2019–2021 Human Frontiers Science Program Fellow, Hubrecht Institute, The Netherlands
2019 PhD, EPFL, Lausanne, Switzerland

Facts & Figures

While being an institution situated near Vienna, ISTA brings together people from many different backgrounds, cultures, and mindsets. It fosters respectful and constructive dialogue and recognizes every individual's inherent worth and dignity, regardless of race, ethnicity, religion, sexual orientation, or any other characteristic.

33.6

Average Employee Age

77

Nationalities at ISTA

North America

Canada
Cuba
El Salvador
Mexico
USA

South America

Argentina
Brazil
Chile
Colombia
Ecuador
Peru
Uruguay

Europe

Albania
Andorra
Austria
Belarus
Belgium
Bosnia
Bulgaria
Croatia
Cyprus
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta
North Macedonia
The Netherlands
Poland
Portugal
Romania
Serbia
Slovakia
Slovenia
Spain
Switzerland
Türkiye
Ukraine
UK

Africa

Benin
Egypt
Kenya
Libya
Nigeria
South Africa

Asia

Afghanistan
Armenia
Bangladesh
China
Georgia
Hong Kong
India
Indonesia
Iran
Israel
Japan
Kazakhstan
Lebanon
Malaysia
Pakistan
Philippines
Russia
Singapore
South Korea
Syria
Taiwan
Turkmenistan
Vietnam

Oceania

Australia

Home countries of ISTA employees
No employees yet – looking forward to your application

Country of Nationality

Less than five people *Scientific and summer intern number throughout 2022, otherwise as of December 31, 2022

Professors & Staff Scientists

As of December 31, 2022

Professors: 67

Female: 13 (19%)
Male: 54 (81%)

Dan Alistarh Distributed Algorithms and Systems
Zhanybek Alpichshev Condensed Matter and Ultrafast Optics
Nick Barton Evolutionary Genetics
Eva Benková Plant Developmental Biology
Carrie Bernecky RNA-based Gene Regulation
Bernd Bickel Computer Graphics and Digital Fabrication
Timothy Browning Analytic Number Theory and its Interfaces
Lisa Bugnet* Stellar Dynamics and Asteroseismology
Krishnendu Chatterjee Computer-aided Verification, Game Theory
Bingqing Cheng Computational Materials Science
Sylvia Cremer Social Immunity
Jozsef Csicsvari Systems Neuroscience
Johann Danzl High-Resolution Optical Imaging for Biology
Mario de Bono Genes, Circuits, and Behavior
Herbert Edelsbrunner Algorithms, Computational Geometry, and Computational Topology
László Erdős Mathematics of Disordered Quantum Systems and Matrices
Xiaoqi Feng* Reproductive Genetics and Epigenetics
Johannes Fink Quantum Integrated Devices
Julian Fischer Theory of Partial Differential Equations, Applied and Numerical Analysis
Stefan Freunberger Materials Electrochemistry
Jiří Friml Developmental and Cell Biology of Plants
Carl Goodrich Theoretical and Computational Soft Matter
Călin Guet Systems and Synthetic Biology of Genetic Networks
Edouard Hannezo Physical Principles in Biological Systems
Tamás Hausel Geometry and its Interfaces
Carl-Philipp Heisenberg Morphogenesis in Development
Monika Henzinger* Algorithms
Thomas A. Henzinger Design and Analysis of Concurrent and Embedded Systems
Martin Hetzer* Protein Homeostasis and Aging
Andrew Higginbotham Condensed Matter and Quantum Circuits
Simon Hippenmeyer Genetic Dissection of Cerebral Cortex Development
Björn Hof Nonlinear Dynamics and Turbulence
Onur Hosten Quantum Sensing with Atoms and Light
Maria Ibáñez Functional Nanomaterials
Peter Jonas Cellular Neuroscience
Maximilian Jösch Neuroethology
Vadim Kaloshin Dynamical Systems, Celestial Mechanics, and Spectral Rigidity
Georgios Katsaros Nanoelectronics
Anna Kicheva Tissue Growth and Developmental Pattern Formation
Rafal Klajn* Nanoscience and Supramolecular Chemistry
Lefteris Kokoris-Kogias Secure, Private, and Decentralized Systems (SPiDerS)
Vladimir Kolmogorov Discrete Optimization
Matthew Kwan Combinatorics and Probability
Christoph Lampert Machine Learning and Computer Vision
Mikhail Lemeshko Theoretical Atomic, Molecular, and Optical Physics
Martin Loose Self-Organization of Protein Systems
Jan Maas Stochastic Analysis
Jorryt Matthee* Astrophysics of Galaxies
Kimberly Modic Thermodynamics of Quantum Materials at the Microscale
Marco Mondelli Data Science, Machine Learning, and Information Theory
Caroline Muller Atmosphere and Ocean Dynamics
Gaia Novarino Genetic and Molecular Basis of Neurodevelopmental Disorders
Jérémie Palacci Materiali Molli
Francesca Pellicciotti* Cryosphere and Mountain Hydrosphere
Bartholomäus Pieber* Catalysis and Synthetic Methodology
Krzysztof Pietrzak Cryptography
Hryhoriy Polshyn Emergent Electronic Phenomena in 2D Materials
Matthew Robinson Medical Genomics
Anđela Šarić Computational Soft and Living Matter
Leonid Sazanov Structural Biology of Membrane Protein Complexes
Paul Schanda Biomolecular Mechanisms from Integrated NMR Spectroscopy
Florian Schur Structural Biology of Cell Migration and Viral Infection
Robert Seiringer Mathematical Physics
Maksym Serbyn Condensed Matter Theory and Quantum Dynamics
Ryuichi Shigemoto Molecular Neuroscience
Sandra Siegert Neuroimmunology in Health and Disease
Michael Sixt Morphodynamics of Immune Cells
Lora Sweeney Evolution, Development, and Function of Motor Circuits
Gašper Tkačik Information Processing in Biological Systems
Beatriz Vicoso Sex-Chromosome Biology and Evolution
Tim Vogels Computational Neuroscience and Neurotheory
Uli Wagner Discrete and Computational Geometry and Topology
Scott Waitukaitis Soft and Complex Materials
Chris Wojtan Computer Graphics and Physics Simulation
Daniel Zilberman Epigenetics and Chromatin

Staff Scientists: 7

(no data due to data protection)

Satish Arcot Jayaram Preclinical Facility
Dániel Balázs Lab Support Facility
Robert Hauschild Imaging & Optics Facility
Walter Kaufmann Electron Microscopy Facility
Mary Muhia Preclinical Facility
Christoph Sommer Imaging & Optics Facility
Jake Yeung Scientific Computing

* will join ISTA in 2023 (see pages 66–69)

One of the aims of this section is to report on gender identity. Due to the lack of available data, this current report can only contain data on the biological sex of an individual as recorded in a government-issued identity document. In this annual report, only people with either the male or female sex are included due to lack of recordings of other sexes and/or in order to keep anonymity.

Campus Community

As of December 31, 2022; percentages are rounded

ISTerns (summer interns): 48

Female: 25 (52%)
Male: 23 (48%)

Scientific interns : 147
(throughout 2022)

Female: 64 (44%)
Male: 83 (56%)

PhD Students: 309

Female: 134 (43%)
Male: 175 (57%)

Postdocs: 176

Female: 60 (34%)
Male: 116 (66%)

Alumni Network: 574

PhD Students/
Graduates: 146 (25%)
Postdocs: 428 (75%)
(at least one year spent at ISTA)

Scientific Staff: 150
(Lab Technicians and SSUs)

Female: 87 (58%)
Male: 63 (42%)

Administrative Staff: 230
(incl. Academic Support)

Female: 135 (59%)
Male: 95 (41%)

PhD Theses

This year, 23 students completed their PhDs, bringing the total number of graduates to 159.

Feyza Nur Arslan
Remodeling of E-cadherin-mediated contacts via cortical flows; Heisenberg Group

Christina Carina Artner
Modulation of auxin transport via ZF proteins adjust plant response to high ambient temperature; Benková Group

Stefanie Belohlavy
The Genetic Basis of Complex Traits Studied via Analysis of Evolve and Resequence Experiments; Barton Group

Morris Brooks
Translation-Invariant Quantum Systems with effectively broken Symmetry; Seiringer Group

Gloria Colombo
MorphOMICs, a tool for mapping microglial morphology, reveals brain region- and sex-dependent phenotypes; Siegert Group

Christoph Dotter
Transcriptional consequences of mutations in genes associated with Autism Apectrum Disorder; Novarino Group

Michelle Gallei
Auxin and strigolactone non-canonical signaling regulating development in *Arabidopsis thaliana*; Friml Group

Marijo Jevtic
Contextual fear learning induced changes in AMPA receptor sub-types along the proximodistal axis in dorsal hippocampus; Shigemoto Group

Olena Kim
Nanoarchitecture of hippocampal mossy fiber-CA3 pyramidal neuron synapses; Jonas Group

Nikola Hristov Konstantinov
Robust and Fair Machine Learning; Lampert Group

Mathias Lechner
Learning Verifiable Representations; Henzinger Group

Lenka Matejovicova
Genetic basis of flower colour as a model for adaptive evolution; Barton Group

Sina Metzler
Pathogen-mediated sexual selection and immunization in ant colonies; Cremer Group

Krzysztof Myśliwy
Polarons in Bose gases and polar crystals. Some rigorous energy estimates; Seiringer Group

Michele Nardin
On the encoding, transfer, and consolidation of spatial memories Csicsvari Group

Wojciech Zbigniew Rządkowski
Analytic and machine learning approaches to composite quantum impurities; Lemeshko Group

Elena Redchenko
Controllable states of superconducting Qubit ensembles; Fink Group

Rouven Schulz
Chimeric G protein-coupled receptors mimic distinct signaling pathways and modulate microglia function; Siegert Group

Alec Leonard Shute
Existence and density problems in Diophantine geometry: From norm forms to Campana points; Browning Group

Georg Sperl
Homogenizing yarn simulations: Large scale mechanics, small-scale detail, and quantitative fitting; Wojtan Group

Saren Tasciyan
Role of microenvironment heterogeneity in cancer cell invasion; Sixt Group

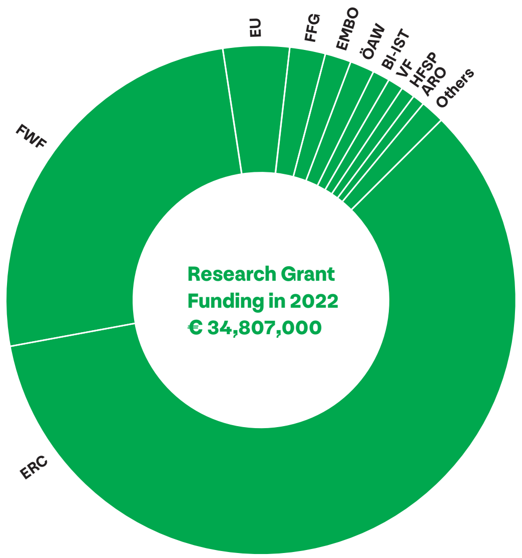
Stephanie Wachner
Transcriptional Regulations by Dfos and BMP-Signaling Support Tissue Invasion of *Drosophila* Immune Cells; Siekhaus Group

Pascal Frederik Wild
High-dimensional expansion and crossing numbers of simplicial complexes; Wagner Group

Fields of Research

Grants

Active or received third-party funding in 2022; funding amounts are rounded



€ 20,743,000	ERC	€ 529,000	Others, including:
€ 8,877,000	FWF	€ 155,000	VW
€ 1,465,000	EU	€ 99,000	UCL
€ 788,000	FFG	€ 94,000	BKA
€ 577,000	EMBO	€ 64,000	GFF
€ 539,000	ÖAW	€ 37,000	IBM
€ 379,000	BI-IST	€ 18,000	CZI
€ 340,000	VF	€ 14,000	EP
€ 306,000	HFSP	€ 7,000	OeAD
€ 264,000	ARO	€ 41,000	various

Abbreviations

ARO Army Research Office
BIF Boehringer Ingelheim Fonds
BI-IST Boehringer Ingelheim International GmbH
BKA Women Project Funding Austrian Chancellery
BMBWF Bundesministerium für Bildung, Wissenschaft und Forschung
BBRF Brain Behaviour Research Foundation
CZI Chan Zuckerberg Initiative
DFG Deutsche Forschungsgemeinschaft
DOE Department of Energy (USA)
EMBO European Molecular Biology Organization
EIC European Innovation Council
EP Erasmus Plus
ERC European Research Council
FEBS Federation of European Biochemical Societies
FFG Forschungsförderungs-gesellschaft
FWF Austrian Science Fund
GFF Gesellschaft für Forschungsförderung Niederösterreich
HFSP Human Frontier Science Program
HRSM Hochschulraum-Strukturmittel-Projekte
H2020 Horizon 2020*
IBM International Business Machines Corporation
JDRF Juvenile Diabetes Research Foundation
JSPS Japan Society for the Promotion of Science
MSCA Marie Skłodowska-Curie Actions
NFB Niederösterreich Forschung und Bildung
NIH National Institutes of Health
OeAD Agency for Education and Internationalisation
ÖAW Austrian Academy of Sciences
PRACE Partnership for Advanced Computing in Europe
SNF Schweizer Nationalfonds
UCL University College London
VF Vallee Foundation
VW Volkswagen Stiftung
WAW Wirtschaftsagentur Wien
WSS Werner Siemens Stiftung
WWTF Wiener Wissenschafts-, Forschungs-, und Technologiefonds

* Horizon 2020 equals FP8, the eighth Framework Programme for Research and Technological Development 2014–2020, European Union

Alistarh Group

Elastic Coordination for Scalable Machine Learning, ERC StG, €1,494,000; 3/19–2/24

Vienna Graduate School on Computational Optimization, FWF DK, €152,000; 3/20–2/24

Barton Group

The maintenance of alternative adaptive peaks in snapdragons, FWF Stand-alone, €404,000; 3/20–2/23

Dynamics of Wolbachia Spread in *Rhagoletis cerasi*, FWF Stand-alone (Partner, Awardee: Christian Stauffer), €83,000; 9/22–5/26

Causes and consequences of population fragmentation, FWF Stand-alone (Partner, Awardee: Jitka Polechova), €61,000; 9/20–5/24

Integration of speciation research (IOS), ESEB Special Topic Network, €20,000; 9/21–8/23

Understanding the evolution of continuous genomes, ERC AdG, €2,500,000; 9/22–8/27

Polygenic adaptation in a metapopulation, ÖAW DOC, €77,000; 9/22–8/24

The impact of deleterious mutations on small populations, ÖAW DOC, €77,000; 8/22–7/24

Benková Group

Post-Translational Control of CRFs in Plant N Signaling, FWF ESPRIT, €288,000; 2/22–1/25

Breeding for coffee and cocoa root resilience in low input farming systems based on improved rootstock, HE RIA, €375,000; 10/22–9/26

A Role for Auxin-Cytokinin Synergism in Phosphate Starvation and Plant-Fungal Mutualism, ÖAW DOC, €77,000; 12/21–11/23

Plant Hydrotropism – How roots seek water: Molecular mechanism of hydrotropism, FFG FEMtech, €8,000; 12/21–5/22

Mechanism of root system regulation by aromatic cytokinin derivatives, OeAD WTZ, €7,000; 1/21–12/22

Bernecky Group

Regulation of mammalian transcription by noncoding RNA, FWF Stand-alone, €400,000; 11/20–10/23

Roles of A-to-I editing in dsRNA recognition, FWF SFB, €244,000; 3/20–2/24

Bickel Group

MATERIALIZABLE: Intelligent fabrication-oriented Computational Design and Modeling, H2020 ERC StG, €1,498,000; 2/17–1/22

Perception-Aware Appearance Fabrication, FWF Meitner, €164,000; 12/21–12/23

Browning Group

New frontiers of the Manin conjecture, FWF Stand-alone, €362,000; 10/19–9/22

A motivic circle method, H2020 MSCA IF, €186,000; 7/20–1/22

Rational curves via function field analytic number theory, FWF Stand-alone, €361,000; 12/22–11/25

Chatterjee Group

Formal Methods for Stochastic Models: Algorithms and Applications, ERC CoG, €1,998,000; 1/21–12/25

Graphical Games, FFG FEMtech, €8,500; 11/22–4/23

Cheng Group

Development of a protective inorganic interface for using metallic Mg anodes in next-generation Mg-ion batteries, FFG Energieforschung, €213,000; 1/23–12/26

Cremer Group

Epidemics in ant societies on a chip, H2020 ERC CoG, €1,992,000; 4/18–3/23

Brushing off pathogens: structure and function of the antennal cleaner in ants, ÖAW DOC, €116,000; 10/20–9/23

Csicsvari Group

Respiratory-mediated regulation of hippocampal-cortical dynamics in emotional memory reactivation, BBRF Young Investigator Grants, €30,000; 1/22–1/23

Danzl Group

CryoMinflux-guided in-situ visual proteomics and structure determination, CZI Visual Proteomics, €427,000; 8/21–1/24

High content imaging to decode human immune cell interactions in health and allergic disease, NFB Life Science, €279,000; 12/19–11/22

Molecular Drug Targets, FWF DK, €214,000; 3/19–2/24

Studying organelle structure and function at nanoscale resolution with expansion microscopy, ÖAW DOC, €77,000; 8/21–7/23

de Bono Group

Molecular mechanisms of neural circuit function, Wellcome Trust Investigator Award, €1,223,000; 10/19–3/23

Role of IL-17 signaling effectors MALT-1 and NFKI-1, FWF Meitner, €178,000; 2/22–1/24

Control of gene expression at the endoplasmic reticulum, EMBO LTF, €105,000; 10/19–2/22

Regulation of mRNA expression at the ER, FWF ESPRIT, €294,000; 8/22–7/25

Edelsbrunner Group

Alpha Shape Theory Extended, H2020 ERC AdG, €1,678,000; 7/18–6/23

The Wittgenstein Prize–Herbert Edelsbrunner, FWF Wittgenstein, €1,400,000; 7/19–6/24

Discretization in Geometry and Dynamics, FWF SFB, €290,000; 10/20–9/24

Algebraic Footprints of Geometric Features in Homology, FWF International program, €234,000; 10/19–9/22

Learning and triangulating manifolds via collapses, FWF Meitner, €178,000; 6/21–1/23

Erdős Group

Random matrices beyond Wigner-Dyson-Mehta, ERC AdG, €1,912,000; 10/21–9/26

Fink Group

A Fiber Optic Transceiver for Superconducting Qubits, H2020 ERC StG, €1,500,000; 2/18–1/23

Protected states of quantum matter, NOMIS Research Grants, €550,000; 2/22–1/26

Integrating superconducting quantum circuits, FWF SFB, €429,000; 3/19–2/23

Quantum readout techniques and technologies, H2020 Cooperation FET-Open, €388,000; 11/19–4/23

Quantum Local Area Networks with Superconducting Qubits, H2020 Cooperation FET-Open, €388,000; 9/20–8/23

Protected states of quantum matter, NOMIS Research Grants, €550,000; 2/22–1/26

Fischer Group

Bridging Scales in Random Materials, H2020 ERC StG, €1,143,000; 3/21–2/26

Taming Complexity in Partial Differential Systems, FWF SFB, €203,000; 3/21–2/25

Freunberger Group

Energy storage with bulk liquid redox materials, ERC PoC, €150,000; 5/22–10/23

Multifunktionales Energiespeichermaterial auf Basis von flüssigem Phosphor und Phosphorsäureester-Derivaten, FFG Energieforschung, €9,000; 9/22–8/23

Friml Group

Tracing Evolution of Auxin Transport and Polarity in Plants, H2020 ERC AdG, €2,410,000; 1/18–12/22

Molecular mechanisms of endocytic cargo recognition in plants, FWF International program, €339,000; 2/18–1/22

Plant Hormone Auxin, FFG FEMtech, €8,000; 7/22–12/22

Tailored molecular adaptation to drought: A soybean case study, NFB FTI-Call, €13,000; 6/22–9/24

Peptide receptor complexes for auxin canalization and regeneration in *Arabidopsis*, FWF International program, €406,000; 9/22–8/26

Identification of a novel regulator in auxin canalization, FWF ESPRIT, €294,000; 12/22–11/25

Guet Group

CyberCircuits: Cybergenetic circuits to test composability of gene networks, FWF International program, €262,000; 4/19–3/23

Dynamics of large evolutionary steps at the level of the single cell, EMBO LTF, €136,000; 1/21–2/23

Bacterial cytoplasm glass transition: passive physiological switch or active survival strategy, EMBO LTF, €136,000; 8/21–7/23

Genetic Mobility, FFG FEMtech, €8,000; 10/22–3/23

Uncovering the Organisational Principle of Bacterial Genomic Islands in Anti-phage Defense, ÖAW DOC, €77,000; 8/22–7/24

Evolutionary analysis of gene regulation, FWF International program, €309,000; 7/22–2/25

Hannezo Group

Design Principles of Branching Morphogenesis, H2020 ERC StG, €1,453,000; 7/20–6/25

Active mechano-chemical description of the cell cytoskeleton, FWF Stand-alone, €339,000; 10/18–9/22

Biomechanics of stem cell fate determination, EMBO LTF, €136,000; 8/21–7/23

EMBO Young Investigator Program, EMBO, €15,000; 1/20–12/23

Motile active matter models of migrating cells and chiral filaments, ÖAW DOC, €77,000; 7/22–6/24

Hausel Group

Branes on hyperkähler manifolds, ÖAW DOC, €77,000; 10/21–9/23

Geometry of the tip of the global nilpotent cone, FWF Stand alone, €378,000; 10/22–9/25

Topology of open smooth varieties with a torus action, ÖAW DOC, €77,000, 7/22–6/24

Heisenberg Group

Interaction and feedback between cell mechanics and fate specification in vertebrate gastrulation, H2020 ERC AdG, €2,307,000; 7/17–6/22

Control of embryonic cleavage pattern, FWF International program, €229,000; 5/18–4/22

Nano-Analytics of Cellular Systems, FWF DK, €197,000; 3/18–8/23

Dissecting the mechanisms underlying cytoplasmic reorganization and embryo patterning in ascidians, HFSP LTF, €194,000; 7/21–6/24

Coordination of mesendoderm fate specification and internalization during zebrafish gastrulation, HFSP LTF, €144,000; 9/18–2/22

Tissue morphogenesis driven by feedback regulations between fluidization and kinase activation, JSPS ORF, €100,000; 4/21–3/23

Bridging biophysics and evolution: impact of intermediate filament evolution on tissue mechanics, HFSP Research grant, €306,000; 9/22–8/25

Cytoplasmic reorganization in zebrafish oocytes, FWF Stand alone, €366,000; 11/22–10/25

Henzinger Group

Vigilant Algorithmic Monitoring of Software, ERC AdG, €2,451,000; 1/22–12/26

Higginbotham Group

Protected states of quantum matter, NOMIS Research Grant, €550,000; 2/22–1/26

Cavity electromechanics across a quantum phase transition, FWF Stand-alone, €406,000; 10/20–9/23

Surface Charge and Tunneling Multi-Mode Imaging, ÖAW DOC, €77,000; 8/21–7/23

Hippenmeyer Group

Principles of Neural Stem Cell Lineage Progression in Cerebral Cortex Development, H2020 ERC CoG, €1,996,000; 12/17–11/22

Molecular Mechanisms of Neural Stem Cell Lineage Progression, FWF SFB, €386,000; 3/20–2/24

3D-Animationsvideo und Virtual Reality-App zur Anwendung der „Mosaik-Analyse mit Doppel-Markern“ in der Stammzellforschung, FWF Wissenschaftskommunikations-programm, €50,000; 3/22–2/23

Molecular Mechanisms Regulating Cortical Neural Stem Cell Lineage Progression and Astrocyte Development, ÖAW DOC, €77,000; 9/22–8/24

Hof Group

Revisiting the Turbulence Problem Using Statistical Mechanics: Experimental Studies on Transitional and Turbulent Flows, Simons Foundation MPS Targeted Grants, €872,000; 9/19–8/23

Instabilities in pulsating pipe flow of Newtonian and complex fluids, FWF International program, €356,000; 1/20–12/22

Ibáñez Group

HighTE: The Werner Siemens Laboratory for the High Throughput Discovery of Semiconductors for Waste Heat Recovery, WSS, €8,000,000; 9/20–8/28

Mediated Biphasic Battery, EIC Pathfinder Open, €380,000; 5/22–4/25

Bottom-up Engineering for Thermoelectric Applications, FWF Meitner, €162,000; 5/20–4/22

Solar-Light-Driven Photoelectrochemical System, OeAD WTZ, €8,000; 1/21–10/22

Jonas Group

Biophysics and circuit function of a giant cortical glumatergic synapse, H2020 ERC AdG, €2,678,000; 3/17–8/22

The Wittgenstein Prize–Peter Jonas, FWF Wittgenstein, €1,530,000; 10/17–3/23

Intracellular hippocampal attractor dynamics, FWF Firnberg, €254,000; 9/19–9/23

Synaptic computations of the hippocampal CA3 circuitry, HE MSCA IF, €174,000; 1/22–12/23

Jösch Group

Circuits of Visual Attention, H2020 ERC StG, €1,447,000; 12/17–11/22

Evolution of Sensorimotor Transformation Across Diptera, DFG Priority Program, €343,000; 3/21–2/24 (grant received together with Fyodor Kondrashov)

Determining the Molecular Logic of Direction-Selective Wiring Program, BIF PhD Fellowship, €59,000; 1/22–12/23

Kaloshin Group

Spectral rigidity and integrability for billiards and geodesic flows, H2020 ERC AdG, €1,821,000; 3/21–2/26

Katsaros Group

Protected states of quantum matter, NOMIS Research Grant, €550,000; 2/22–1/26

Topologically protected and scalable quantum bits, H2020 Cooperation FET-Open, €504,000; 12/19–8/23

Towards scalable hut wire quantum devices, FWF Stand-alone, €411,000; 10/19–9/23

Hole spin orbit qubits in Ge quantum wells, FWF Stand-alone, €410,000; 2/18–1/22

High impedance circuit quantum electrodynamics with hole spins, FWF International program, €399,000; 6/21–5/24

Integrated Germanium Quantum Technology, HE RIA, €260,000; 7/22–6/25

Kicheva Group

Morphogen control of growth and pattern in the spinal cord, FWF SFB, €375,000; 3/20–2/24

The role of morphogens in the regulation of neural tube growth, ÖAW DOC, €115,000; 10/18–2/22

The regulatory logic of pattern formation in the vertebrate dorsal neural tube, NFB Science Call Dissertationen, €60,000; 4/20–3/23

Mechanisms of tissue size regulation in spinal cord development, ERC CoG, €1,993,000; 12/22–11/27

Kolmogorov Group

Vienna Graduate School on Computational Optimization, FWF DK, €152,000; 3/20–2/24

Kondrashov Group

Characterizing the fitness landscape on population and global scales, H2020 ERC CoG, €1,419,000; 1/19–6/22

Evolutionary analysis of gene regulation, FWF International program, €86,000; 3/21–6/22 (Transferred to Guet)

Evolution of Sensorimotor Transformation Across Diptera, DFG Priority Program, €78,000; 3/21–4/22 (grant received together with Maximilian Jösch)

Lemeshko Group

Angulon: physics and applications of a new quasiparticle, H2020 ERC StG, €1,500,000; 2/19–1/24

Analytic and machine learning approaches to composite quantum impurities, ÖAW DOC, €57,000; 3/20–3/22

Loose Group

Understanding bacterial cell division by in vitro reconstitution, FWF Stand-alone, €389,000; 9/21–8/24

EMBO Young Investigator Program, EMBO, €15,000; 1/20–12/23

Characterization of FtsA mutants in the context of bacterial cell division, FFG FEMtech, €6,000; 10/21–1/22

Maas Group

Optimal Transport and Stochastic Dynamics, H2020 ERC StG, €1,075,000; 2/17–7/22

Taming Complexity in Partial Differential Systems, FWF SFB, €531,000; 3/17–2/25

Reaching consensus in heterogeneous random opinion dynamics, FWF Meitner, €164,000; 11/21–12/22

Curvature-dimension in noncommutative analysis, FWF Meitner, €164,000; 12/21–12/22

Dissipation and Dispersion in Nonlinear Partial Differential Equations, FWF DK, €16,000; 3/17–8/22

Gradient flow techniques for quantum Markov semigroups, FWF ESPRIT, €294,000; 7/22–6/25

Configuration Spaces over Non-Smooth Spaces, FWF ESPRIT, €294,000; 8/22–7/25

Modic Group

Unraveling the mysteries of 1T-TaS2, FWF Stand-alone, €404,000; 4/22–3/25

A new probe of multipole physics in Pr-based compounds, FWF ESPRIT, €300,000; 5/22–4/25

Ground state magnetic properties of $Tb_2Ti_2O_7$ using resonant torsion magnetometry, ÖAW DOC, €77,000; 7/22–6/24

Mondelli Group

Prix Lopez-Loreta 2019 – Marco Mondelli, Fondation Lopez Loreta, €1,000,000; 10/20–9/25

Muller Group

Organization of Clouds, and Implications of Tropical Cyclones and for the Energetics of the Tropics, in Current and Warming Climate; ERC StG, €719,000; 9/21–5/24

Science Data Utilisation and Impact Study for Ocean, ESA, €20,000; 10/21–12/22

Novarino Group

Probing the Reversibility of Autism Spectrum Disorders by Employing in vivo and in vitro Models, H2020 ERC StG, €1,498,000; 10/17–9/22

Critical windows and reversibility of ASD associated with mutations in chromatin remodelers, Simons Foundation Research, €993,000; 8/20–7/24

Neurobiology of anxiety in autism spectrum disorders, FWF FG, € 616,000; 4/22–3/26

Neural stem cells in autism and epilepsy, FWF SFB, €375,000; 3/20–2/24

Molecular Drug Targets, FWF DK, €207,000; 3/15–2/24

Identification of converging Molecular Pathways Across Chromatinopathies as Targets for Therapy, FWF ERA-NET, €359,000; 4/19–3/23

Reducing the impact of major environmental challenges on mental health, HE RIA, €430,000; 6/22–5/27

Studying Autism in cerebral organoids, FFG Praktika, €1'000 9/22–9/22

Toward an understanding of the brain interstitial system and the extracellular proteome in health and autism spectrum disorders, ERC CoG, €1,998,000; 12/22–11/27

Palacci Group

Design, Synchronization and Collective Dynamics of Colloidal Oscillators, FWF Stand-alone, €400,000; 2/22–1/25

Emergent Phenomena in Collection of Autonomous Spinning Microgears Guided by Light, ARO Basic research award, €264,000; 11/22–11/24

Pietrzak Group

Vienna Cybersecurity and Privacy Research Centers, WAW Strukturimpulsprogramm, €40,000; 7/19–6/23

Robinson Group

Improving estimation and prediction of common complex disease risk, SNF Eccellenza, €1,138,000; 5/20–10/24

Advanced statistical modelling to facilitate more accurate characterisation of disease phenotypes, improved genetic mapping, and effective therapeutic hypothesis generation, BI Collaborative research, €379,000; 7/22–7/24

Šarić Group

The evolution of trafficking: from archaea to eukaryotes, Volkswagen Stiftung, €155,000; 1/22–6/24

Non-Equilibrium Protein Assembly: from Building Blocks to Biological Machines, ERC StG, €1,055,000; 1/22–9/24

UCL Studentship, UCL Fellowship, €38,000; 1/22–9/23

UCL Studentship, UCL Fellowship, €33,000; 1/22–7/23

UCL Studentship, UCL Fellowship, €28,000; 1/22–3/23

EMBO Young Investigator, EMBO YIP, €15,000; 1/22–12/24

Modelling cell division and repair by ESCRT-III filaments, Vallee Foundation Vallee Scholar Award, €335,000; 9/22–8/26

Sazanov Group

Structure and mechanism of respiratory chain molecular machines, ERC AdG, €1,781,000; 9/21–8/26

Wittgenstein Award (National research partner, Awardee: Michael Wagner), FWF, €152,000; 7/21–6/23

Schanda Group

AlloSpace. The emergence and mechanisms of allostery, FWF International program, €241,000; 2/22–1/26

Structural determination and dynamics of the mitochondrial import protein (MIM) by cryo-EM and magic-angle-spinning (MAS) nuclear magnetic resonance (NMR), HE MSCA PF, €199,000; 10/22–9/24

Schur Group

CryoMinflux-guided in-situ visual proteomics and structure determination, CZI Visual Proteomics, €419,000; 8/21–1/24

Structure and isoform diversity of the Arp2/3 complex, FWF Stand-alone, €401,000; 7/20–6/23

Structural conservation and diversity in retroviral capsid, FWF Stand-alone, €390,000; 10/18–9/21

Structural characterization of Spumavirus capsid assemblies to understand conserved ortervirales assembly mechanisms, ÖAW DOC, €118,000; 10/20–11/23

Understanding the mechanism and dynamics of chromatin higher-order structure formation via cross-scale structural analysis, OeAD WTZ, €14,000; 8/20–6/23

Integrated visual proteomics of reciprocal cell-extracellular matrix interactions, FEBS Excellence Awards, €100,000; 3/22–2/25

EMBO Young Investigator Program, €15,000; 1/22–12/25

Seiringer Group

Analysis of quantum many-body systems, H2020 ERC AdG, €1,498,000; 10/16–3/22

Serbyn Group

Non-Ergodic Quantum Matter: Universality, Dynamics and Control, H2020 ERC StG, €1,498,000; 2/20–1/25

PhD Fellowship Award, IBM, €37,000; 10/22–6/23

Shigemoto Group

In situ analysis of single channel subunit composition in neurons: physiological implication in synaptic plasticity and behavior, H2020 ERC AdG, €2,481,000; 7/16–6/22

LGI1 antibody-induced pathophysiology in synapses, FWF International program, €256,000; 1/20–12/22

Recombinant Immunolabels for Nanoprecise Brain Mapping Across Scales, NIH U24, €235,000; 9/18–6/24

Novel model systems for studying the role of calcium channel subunits in brain disorders, NFB Life Science, €82,000; 1/21–12/23

Siegert Group

Microglia action towards neuronal circuit formation and function in health and disease, H2020 ERC StG, €1,500,000; 5/17–10/22

How human microglia shape developing neurons during health and inflammation, NFB Science Call Dissertationen, €60,000; 10/20–9/23

Sixt Group

Cellular navigation along spatial gradients, H2020 ERC CoG, €1,985,000; 4/17–3/22

Decoding GPCR signaling to understand chemotaxis, FWF Firnberg, €239,000; 9/19–8/22

Bioelectric patrolling: the role of the local membrane potential in immune cell migration, HFSP LTF, €211,000; 7/21–6/24

Nano-Analytics of Cellular Systems, FWF DK, €157,000; 3/18–8/23

Sweeney Group

Development and Evolution of Tetrapod Motor Circuits, HE ERC StG, €1,500,000; 9/22–8/27

Development of Viral Vectors for Amphibian Gene Delivery and Manipulation, NSF EDGE grant, €190,000; 9/21–8/24

Development of V1 interneuron diversity during swim-to-walk transition of *Xenopus* metamorphosis, GFF Science Call Dissertationen, €64,000; 7/22–6/25

Tkačik Group

Efficient coding with biophysical realism, FWF Stand-alone, €362,000; 12/20–11/23

Can evolution minimize spurious signaling crosstalk to reach optimal performance?, HFSP Program grant, €287,000; 12/18–11/23

Functional Advantages of Critical Brain Dynamics, FWF Meitner, €178,000; 5/22–1/23

Vicoso Group

Prevalence and Influence of Sexual Antagonism on Genome Evolution, H2020 ERC StG, €1,444,000; 3/17–2/22

Mechanisms and Evolution of Reproductive Plasticity, FWF ESPRIT, €288,000, 2/22–1/25

Sexual conflict: resolution, constraints and biomedical implications, ÖAW DOC, €116,000; 8/20–7/23

The highjacking of meiosis for asexual reproduction, FWF SFB, €385,000; 3/22–2/26

Vogels Group

Learning the shape of synaptic plasticity rules for neuronal architectures and function through machine learning, H2020 ERC CoG, €1,769,000; 8/20–5/24

What's in a memory? Spatiotemporal dynamics in strongly coupled recurrent neural networks, Wellcome Trust Residual Award, €1,161,000; 8/20–1/24

Wagner Group

Algorithms for Embeddings and Homotopy Theory, FWF Stand-alone, €404,000; 5/18–4/22

Spectra and topology of graphs and of simplicial complexes, FWF Meitner, €164,000; 7/22–6/24

Waitukaitis Group

Tribocharge: a multi-scale approach to an enduring problem in physics, H2020 ERC StG, €1,494,000; 1/21–12/25

Mit Quincke Rollers mixen, FWF ESPRIT, €294,000; 12/22–11/25

Wojtan Group

Computational Discovery of Numerical Algorithms for Animation and Simulation of Natural Phenomena, ERC CoG, €1,936,000; 6/22–5/27

Zilberman Group

Quantitative analysis of DNA methylation maintenance with chromatin, ERC CoG, €270,000; 7/21–3/23

Evolution of DNA Methylation Machinery and Function across Time, Swedish Research Council Vetenskapsrådet (VR), €310,000; 10/21–9/24

Epigenomic analysis toward quantitative understanding of mechanisms for ectopic DNA methylation, JSPS ORF, €44,000; 10/21–8/22

SSU Grants

Tools for automation and feedback microscopy, CZI Imaging Scientist, ISTA – SSU IOF (Robert Hauschild), €517,000; 12/20–11/23

Napari-correct-drift, CZI Napari Plugin Foundations, ISTA – SSU IOF (Christoph Sommer), €23,000; 11/22–10/23

Twist fellows

R&D Kooperationsvertrag – ISTA-OÖ Wirtschaftsagentur GmbH, FFG Collective research, ISTA – IP & Tech Transfer (Thomas Auzinger), €45,000; 4/22–11/23

Publications

Joint publications involving several groups are listed multiple times

Alistarh Group

Alistarh D-A, Gelashvili R, Rybicki J. 2022. **Fast grapwhical population protocols.** 25th International Conference on Principles of Distributed Systems. OPODIS, LIPIcs, vol. 217, 14.

Alistarh D-A, Rybicki J, Voitovych S. 2022. **Near-optimal leader election in population protocols on graphs.** Proceedings of the Annual ACM Symposium on Principles of Distributed Computing. PODC: Symposium on Principles of Distributed Computing, 246–256.

Brown TA, Sigouin W, Alistarh D-A. 2022. **PathCAS: An efficient middle ground for concurrent search data structures.** Proceedings of the 27th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming. PPoPP: Sympopsium on Principles and Practice of Parallel Programming, 385–399.

Balliu A, Hirvonen J, Melnyk D, Olivetti D, Rybicki J, Suomela J. 2022. **Local mending.** International Colloquium on Structural Information and Communication Complexity. SIROCCO: Structural Information and Communication ComplexityLNCS vol. 13298, 1–20.

Iofinova EB, Peste E-A, Kurtz M, Alistarh D-A. 2022. **How well do sparse ImageNet models transfer?** 2022 IEEE/CVF Conference on Computer Vision and Pattern Recognition. CVPR: Computer Vision and Pattern Recognition, 12256–12266.

Nikabadi A, Korhonen J. 2022. **Beyond distributed subgraph detection: Induced subgraphs, multicolored problems and graph parameters.** 25th International Conference on Principles of Distributed Systems. OPODIS, LIPIcs, vol. 217, 15.

Postnikova A, Koval N, Nadiradze G, Alistarh D-A. 2022. **Multi-queues can be state-of-the-art priority schedulers.** Proceedings of the 27th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming. PPoPP: Sympopsium on Principles and Practice of Parallel Programming, 353–367.

Pacut M, Parham M, Rybicki J, Schmid S, Suomela J, Tereshchenko A. 2022. **Brief announcement: Temporal locality in online algorithms.** 36th International Symposium on Distributed Computing. DISC: Symposium on Distributed Computing vol. 246, 52.

Shevchenko A, Kungurtsev V, Mondelli M. 2022. **Mean-field analysis of piecewise linear solutions for wide ReLU networks.** Journal of Machine Learning Research. 23(130), 1–55.

Alpichshev Group

Dziom U, Shuvaev A, Gospodarič J, Novik EG, Dobretsova AA, Mikhailov NN, Kvon ZD, Alpichshev Z, Pimenov A. 2022. **Universal transparency and asymmetric spin splitting near the Dirac point in HgTe quantum wells.** Physical Review B. 106(4), 045302.

Shuvaev A, Dziom U, Gospodarič J, Novik EG, Dobretsova AA, Mikhailov NN, Kvon ZD, Pimenov A. 2022. **Band structure near the Dirac Point in HgTe quantum wells with critical thickness.** Nanomaterials. 12(14), 2492.

Barton Group

Barton NH, Olusanya OO. 2022. **The response of a metapopulation to a changing environment.** Philosophical Transactions of the Royal Society B: Biological Sciences. 377(1848).

Barton NH. 2022. **The 'New Synthesis'.** Proceedings of the National Academy of Sciences of the United States of America. 119(30), e2122147119.

Freitas S, Westram AM, Schwander T, Arakelyan M, Ilgaz Ç, Kumlutas Y, Harris DJ, Carretero MA, Butlin RK. 2022. **Parthenogenesis in *Darevskia* lizards: A rare outcome of common hybridization, not a common outcome of rare hybridization.** Evolution. 76(5), 899–914.

Hearn KE, Koch EL, Stankowski S, Butlin RK, Faria R, Johannesson K, Westram AM. 2022. **Differing associations between sex determination and sex-linked inversions in two ecotypes of *Littorina saxatilis*.** Evolution Letters. 6(5), 358–374.

Hledik M, Barton NH, Tkačik G. 2022. **Accumulation and maintenance of information in evolution.** Proceedings of the National Academy of Sciences. 119(36), e2123152119.

Hayward L, Sella G. 2022. **Polygenic adaptation after a sudden change in environment.** eLife. 11, 66697.

Koch EL, Ravinet M, Westram AM, Johannesson K, Butlin RK. 2022. **Genetic architecture of repeated phenotypic divergence in *Littorina saxatilis* evolution.** Evolution. 76(10), 2332–2346.

Lagator M, Sarikas S, Steinrueck M, Toledo-Aparicio D, Bollback JP, Guet CC, Tkačik G. 2022. **Predicting bacterial promoter function and evolution from random sequences.** eLife. 11, e64543.

Sachdeva H, Olusanya OO, Barton NH. 2022. **Genetic load and extinction in peripheral populations: The roles of migration, drift and demographic stochasticity.** Philosophical Transactions of the Royal Society B. 377(1846), 20210010.

Surendranadh P, Arathoon LS, Baskett C, Field D, Pickup M, Barton NH. 2022. **Effects of fine-scale population structure on the distribution of heterozygosity in a long-term study of *Antirrhinum majus*.** Genetics. 221(3), iyac083.

Saona Urmeneta RJ, Kondrashov F, Khudiakova K. 2022. **Relation between the number of peaks and the number of reciprocal sign epistatic interactions.** Bulletin of Mathematical Biology. 84(8), 74.

Szep E, Trubenova B, Csilléry K. 2022. **Using gridCoal to assess whether standard population genetic theory holds in the presence of spatio-temporal heterogeneity in population size.** Molecular Ecology Resources. 22(8), 2941–2955.

Stankowski S. 2022. **Digest: On the origin of a possible hybrid species.** Evolution. 76(11), 2784–2785.

Turelli M, Barton NH. 2022. **Why did the Wolbachia transinfection cross the road? Drift, deterministic dynamics, and disease control.** Evolution Letters. 6(1), 92–105.

Westram AM, Faria R, Johannesson K, Butlin R, Barton NH. 2022. **Inversions and parallel evolution.** Philosophical Transactions of the Royal Society B: Biological Sciences. 377(1856), 20210203.

Westram AM, Butlin R. 2022. **Professor Kerstin Johannesson–winner of the 2022 Molecular Ecology Prize.** Molecular Ecology. 32(1), 26–29.

Westram AM, Stankowski S, Surendranadh P, Barton NH. 2022. **What is reproductive isolation?** Journal of Evolutionary Biology. 35(9), 1143–1164.

Westram AM, Stankowski S, Surendranadh P, Barton NH. 2022. **Reproductive isolation, speciation, and the value of disagreement: A reply to the commentaries on 'What is reproductive isolation?'** Journal of Evolutionary Biology. 35(9), 1200–1205.

Benková Group

Abualia R, Ötvös K, Novák O, Bouguyon E, Domanegg K, Krapp A, Nacry P, Gojon A, Lacombe B, Benková E. 2022. **Molecular framework integrating nitrate sensing in root and auxin-guided shoot adaptive responses.** Proceedings of the National Academy of Sciences of the United States of America. 119(31), e2122460119.

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Wojtan Group

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SSUs

Electron Microscopy Facility

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Imaging & Optics Facility

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Nanofabrication Facility

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Nuclear Magnetic Resonance Facility

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Pre-Clinical Facility

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Scientific Data 2022

Barton Group

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Loose Group

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Siegert Group

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Awards

Scientific Awards and Distinctions 2022
(selection)

Cross of Honor for Science and Art
Thomas A. Henzinger

ERC Advanced Grant
Nick Barton

ERC Consolidator Grant
Martin Loose, Anna Kicheva, Gaia Novarino, Chris Wojtan

ERC Proof of Concept Grant
Stefan Freunberger

ERC Starting Grant
Matthew Kwan, Kimberly Modic, Florian Schur

ERC Synergy Grant
Michael Sixt

Human Frontier Science Program Grant
Carl-Philipp Heisenberg

Magdalena Walz Professor for Life Sciences
Peter Jonas

VERBUND Professor for Energy Science
Maria Ibáñez

Vallee Scholars Award
Anđela Šarić

Member of the Academia Europaea
Timothy Browning

Member of the Young Academy (Austria)
Edouard Hannezo

Pierre Gilles de Gennes Prize
Anđela Šarić

ISTA Internal Awards 2022

Outstanding Scientific Achievement
Marco Valentini, PhD student Katsaros Group

Outstanding Scientific Support
Katharina Bauer, Preclinical Facility Colony Manager

Outstanding Administrative Support
Uli Seiss, Graduate School Office
Niall O'Brian, Grant Office

Outstanding PhD Thesis
Kathrin Tomasek, Sixt and Guet groups

Alumni Award
Anton Mellit, former postdoc Hausel Group

Golden Chalk Award for Excellence in Teaching
Zhanybek Alpichshev

Golden Sponge Award for Excellent Teaching Assistance
Sarath Sankar Suresh

Events

Scientific Conferences, Workshops, and Symposia
(selection)

May 22–27
Les Houches-TSRC Workshop on Protein Dynamics
Forum for presenting, teaching, and discussing results from the application of state-of-the-art experimental, theoretical and computational approaches to studying protein dynamics.

June 21
Austrian Computer Science Day
Forum to bring together computer scientists in Austria.

September 7–8
SLC13a5 Research Roundtable
Research roundtable to gather international research and clinical experts in SLC13A5 citrate transporter disorder.

September 13
EBRAINS Workshop
Workshop to introduce participants to the EBRAINS research infrastructure.

September 14–16
Selected Topics in Evolutionary Biology (STEB) Student Visit
The top students who participated in last year's STEB course visited the campus and heard talks about evolutionary research.

October 5–7
GAMM Activity Group
Annual workshop of the GAMM Activity Group on Analysis of PDEs.

October 21
Soft Matter Conference
Conference to establish a coherent soft matter community throughout the greater Vienna area.

Outreach and Science Education Events
(selection)

March 3
Science Education Seminar
Seminar on bringing MINT topics into practice in schools.

March 30
Science Education Day – "Eine Welt voll Daten"
Teachers eager to strengthen their data literacy teaching skills attended this event to exchange ideas and learn about classroom activities.

April 28
Girls' Day
Meeting to introduce girls to and encourage them to explore the world of scientific work.

June 25
Open Campus
ISTA's annual open house, where all are invited to discover basic research with hands-on experiments, lab tours, and other activites.

July 15
Kinderuni Workshop Day on Campus
On-campus workshop for children aged 7 to 12 organized by the Kinderbüro Wien.

August 8–12
Sommercampus Kids
Week-long summer camp for children aged six to ten.

August 16–19
Sommercampus Juniors
Four-day summer camp for children aged 11 to 14.

August 23–25
Fakebusters Bootcamp
One-week summer camp for teenagers.

October 20
Young Scientists Symposium
Organized by graduate students, this symposium brings together all research disciplines at ISTA in one dedicated topic. The theme for 2022 was energy.

November 8
WoMen in Science
Podium discussion highlighting the importance of gender balance in research and innovation.

Public Lectures

May 13
Venki Ramakrishnan (MRC)
ISTA Lecture
"Initiation of translation in eukaryotes and bacteria"

May 16
Stuart Russell (UC Berkeley)
ISTA Lecture
"Provably Beneficial Artificial Intelligence"

May 31
Michael Ghil (Ecole Normale Superieure & UCLA)
ISTA Science and Sustainability Seminar
"The Death of Stationarity and the Runaway Greenhouse"

June 9
Paul Schanda (ISTA)
ISTA Science Talk
"Wie Proteine einander falten und fit halten: die faszinierende Welt der Chaperone"

September 19
Yann LeCun (New York University and Meta)
ÖAW – ISTA Lecture
"From machine learning to autonomous intelligence"

November 10
Misha Glenny (Institute for Human Sciences)
ISTA Science and Society Lecture
"Russia, Cybercrime, and the Problem of Scale"

Institute Colloquia

January 24
Henry Adams (Colorado State University)
Topology in Machine Learning

January 31
Yang Shao-Horn (MIT)
Scientific Challenges Towards Mitigating Climate Change

February 24
Christian Koeberl (University of Vienna)
The Terrestrial Impact Record: From Geochemical Confirmation to Planetary Defense

March 7
Jeanne Stachowiak (The University of Texas at Austin)
Disordered protein networks as synergistic drivers of membrane traffic

March 14
Maya Cakmak (University of Washington)
Robot programming for all

March 21
Sarah Cohen (University of North Caroloina at Chapel Hill)
Illuminating organelle dynamics and lipid trafficking

March 28
Romana Schirhagl (University of Groningen)
Relaxometry for measuring free radical generation in living cells

April 25
Olgica Milenkovic (University of Illinois at Urbana-Champaign)
Generalized page rank applications: From local community detection to graph neural networks

May 16
Zoltan Haiman (Columbia University)
The formation and growth of massive black holes

May 30
Roser Valenti (Goethe University Frankfurt)
Strategies to design quantum materials with exotic properties

September 19
Kristen M. Harris (University of Texas at Austin)
Structural synaptic plasticity as a basis for spaced learning

September 23
Gina Turrigiano (Brandeis University)
The ups and downs of firing rate homeostasis

October 10
Artur Avila (University of Zurich)
Renormalization, fractal geometry, and the Newhouse phenomenon

October 17
Adrian Tompkins (ICTP)
Does the Earth have a meso scale water vapour iris?

October 24
Judit Szulagyi (ETH Zurich)
How do planets and moons form? Can we observe them with the new generation of telescopes?

November 7
Benny Sudakov (ETH Zurich)
Emergence of regularity in large graphs

November 14
Vincent Taisson (ETH Zurich)
Robust results in percolation theory

November 21
Marja Timmermans (University of Tübingen)
Making a flat leaf: Pre-patterning, morphogenic small RNAs, and Turing reactions

November 28
Shiri Artstein-Avidan (Tel Aviv University)
Measure transportation and duality

December 5
Philip Kim (Harvard University)
Stacking van der Waals atomic layers: quest for new atomic materials

December 12
Alon Orlitsky (University of California San Diego)
Randomized maximum selection and ranking

December 19
Giulia Galli (University of Chicago)
Complex materials from first principles: from sustainable energy sources to quantum information science

Technology Transfer Talks

March 9
Eva Sommer (Fermify)
TWIST Talk
"How to use Deep Tech to Make Cows Obsolete"

June 28
Stefano Coss (Arteria Technologies GmbH)
TWIST Talk
"From Science to Entrepreneurship. A truly rewarding experience"

September 9
Priyanka Dutta (Healiva SA)
TWIST Talk
"Reflection on my journey from Academia to industry"

October 11
Bernd Bickel (ISTA), Daniela Buchmayer (CEO Sarcura), Johannes Fink (ISTA), Stefan Freunberger (ISTA), Christoph Huber (Co-Founder BioNTech), Stefan Poledna (CTO TTTech), Matthew Robinson (ISTA), Friedrich Scheiflinger (EVP Evotech)
Science Industry Talk
Panel discussion on "Translating science into business – Lessons from an emerging ecosystem"

October 19
Tamara Gerbert (Brightmind)
TWIST Talk
Closed-loop non-invasive brain stimulation

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6 Sports Facilities

66,540 m²

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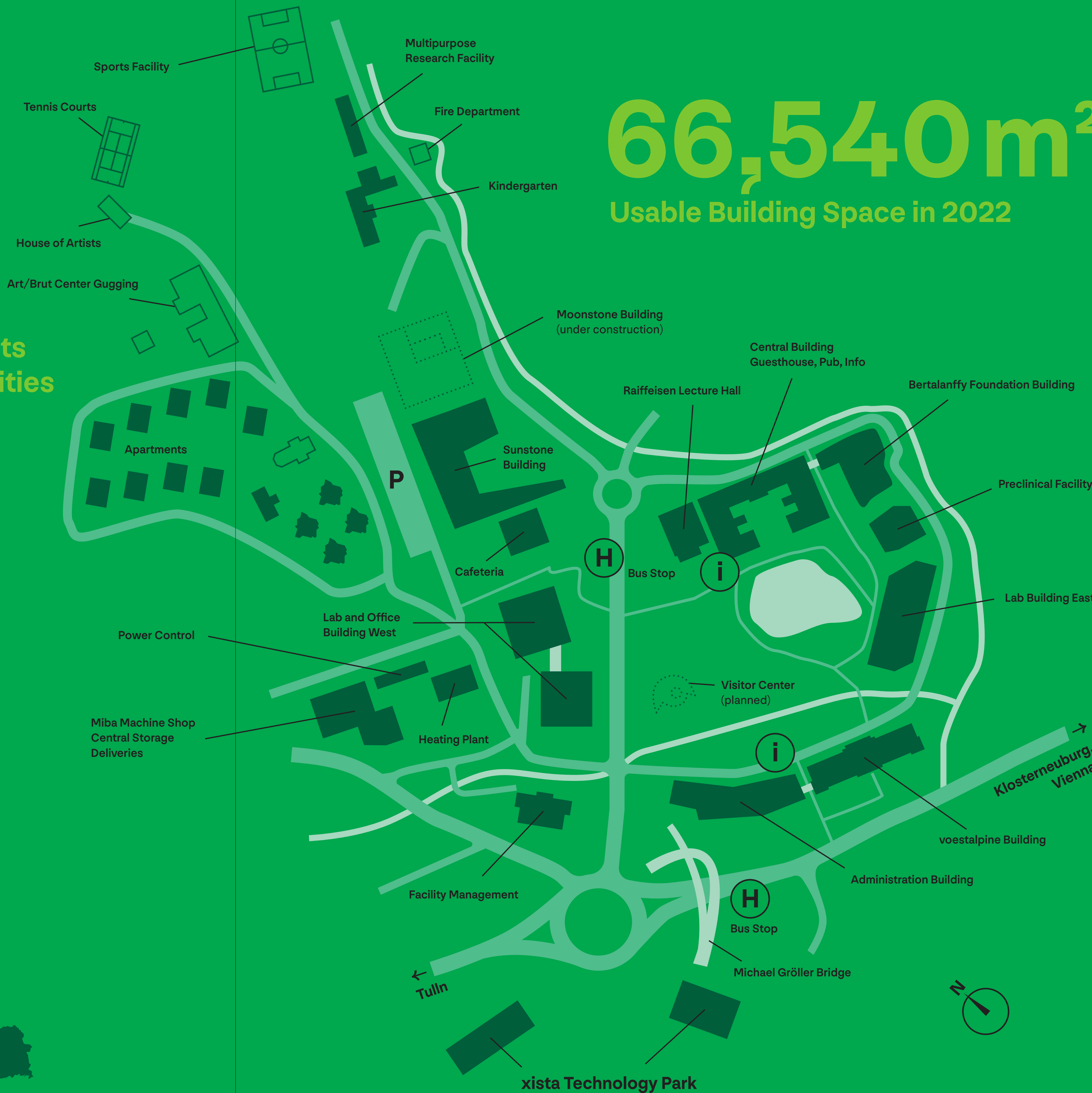

Imprint

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Production and Print
gugler* print GmbH
Cradle-to-cradle print

Font
Nouvelle Grotesk
(Nouvelle Noire)

Paper
PERGRAPHICA®
High White Rough 120 g/m²
Classic Smooth 300 g/m²

PurePrint® by gugler* drucksinn.at

FSC® C005108

klimapositiv gedruckt

UW-Nr. 609