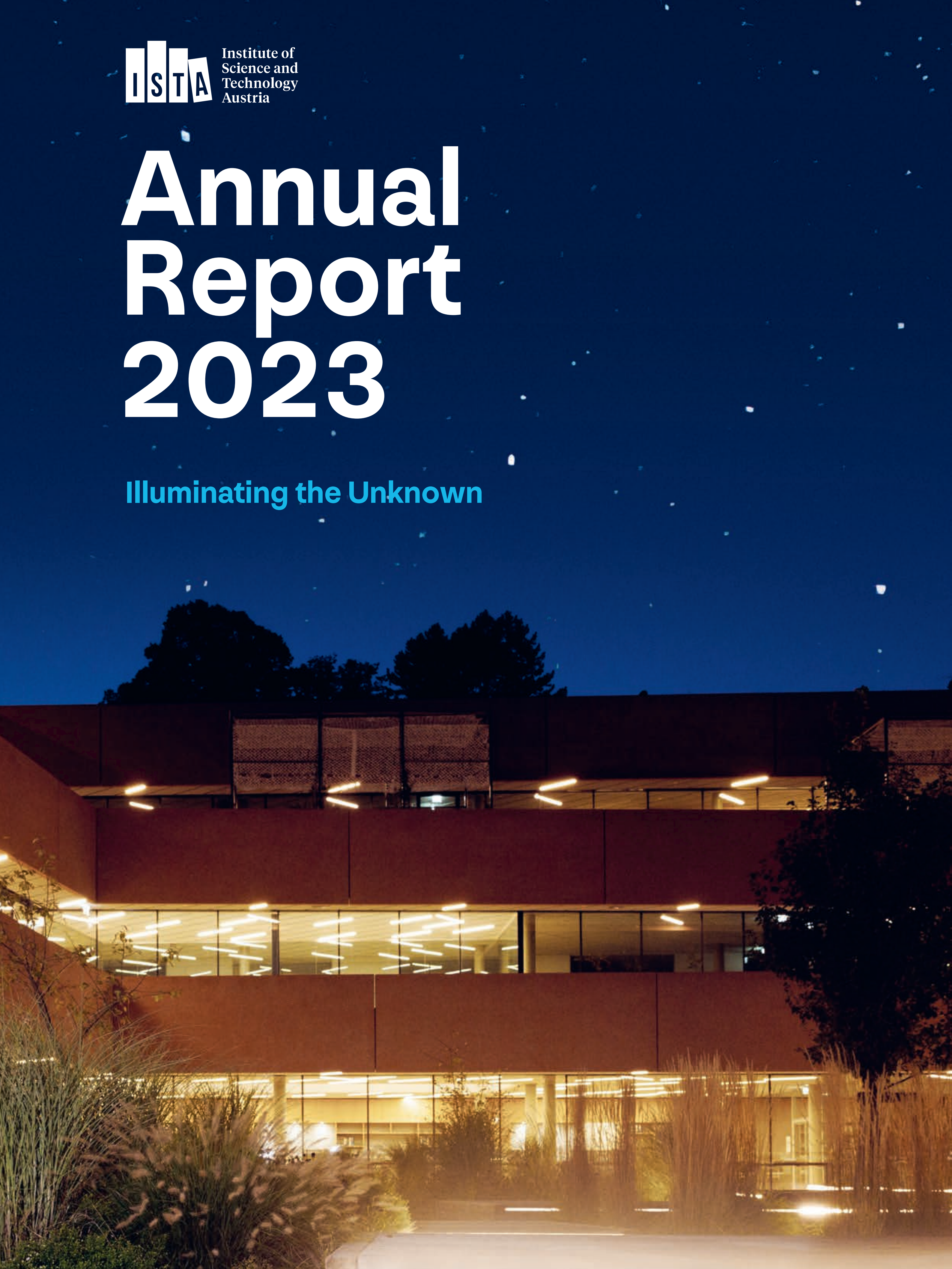
Institute of Science and Technology Austria

Annual Report 2023

Illuminating the Unknown



Annual Report 2023
Illuminating the Unknown

Institute of
Science and
Technology
Austria

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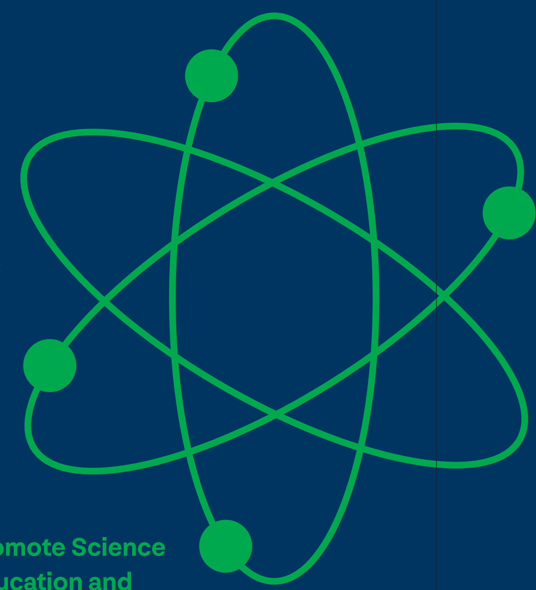
At a Glance

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.

Core Missions



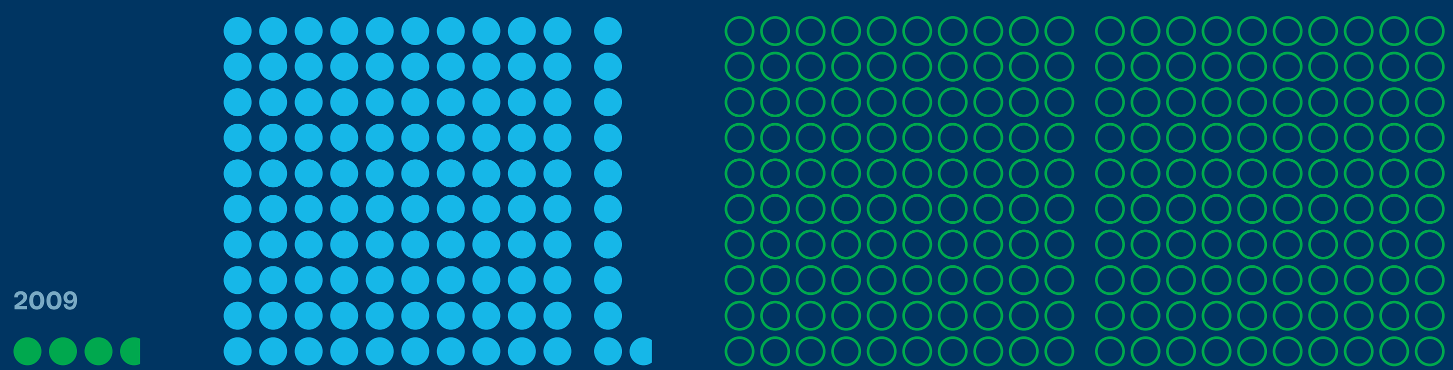
Perform World-Class Research

Train the Next Generation of Scientific Leaders

Implement Best Practices in Science Management

Promote Science Education and Tech Transfer

Growth in the Number of Employees



2009: 37 employees, 4 research groups

2023: 1,108 employees, 77 research groups

2036: 2,000 employees, 150 research groups (estimated)

63 ERC Grants

Including Proof of Concept ERCs, excluding 18 transferred to ISTA

78 Nationalities Working at ISTA

Founding Principles

Under the leadership of President Martin Hetzer, the Institute is 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

Illuminating the Unknown

Being a scientific pioneer is not merely about accumulating knowledge. It involves embarking on a journey into the unknown, taking a leap into uncharted territories beyond familiar horizons. Our mission, rooted in the heart of science, is to explore previously uninvestigated areas of research. Science, often perceived as a creator of knowledge, truly excels in unveiling new mysteries. It is through our dedication to systematic skepticism and rigorous research that we navigate these unexplored territories, enhancing our collective understanding. Importantly, science does not tell us what we want to hear; it tells us the truths we need to hear. It provides a compass that allows us to navigate through uncertainty, especially in times of rapid and profound changes like ours. Our commitment at ISTA to this pursuit is not just a choice, but a necessity for progress.

At ISTA, we strive to be uniquely curious and look beyond the traditional boxes. The first year of my presidency afforded me the privilege of getting to know the people behind the Institute's success—brilliant scientists, dedicated employees, and unwavering supporters. When I inquired about what they valued most about ISTA, they pinpointed the blue-sky freedom to pursue one's research ideas. They also highlighted the opportunities that foster new connections across traditional disciplines and the abundance of world-class equipment and facilities enabling progress around the clock. These elements are prerequisites for the scientific excellence we promise to uphold. I am elated that my inaugural year mirrored ISTA's commitment to highest quality, ambitious growth, and inventive implementation.

This year, ISTA launched into space—by welcoming the first three astrophysics professors on campus. Seven additional research groups, spanning chemistry, glaciology, epigenetics, algorithms, and machine learning, signify a record year for new hires. With 76 research groups and 1,108 employees, we align with the targeted trajectory toward the long-term goal of 150 groups and 2,000 employees by 2036. Such growth necessitates new space. The opening of the Moonstone Building marked a milestone, concluding the second of three campus expansion phases. This laboratory building is not only home to astrophysicists, climate scientists, soft matter physicists, and computer scientists, but it also offers, with its modern seminar center, new possibilities for hosting international conferences and events.

Another testament to its pioneering mindset is the Institute's strong pledge to bridge science and society proactively. On the one hand, xista epitomizes a powerful innovation ecosystem, channeling scientific insights into relevant applications, funding promising ventures, and hosting them on campus at the xista science park. On the other hand, our educational program, VISTA Science Experiences, makes research accessible to everyone. The diverse activities engage the public, from schoolchildren to grandparents, with the awe of scientific inquiry. Two newly established annual ISTA residencies, in science journalism and art, further explore innovative ways to convey the beauty of science through storytelling and creativity.

I encourage you to consider this year's report as a source of inspiration, to venture out, look beyond your known horizons, into a clear starry night sky, and feel the sublimity of the universe around us. Then, allow yourself to formulate a question and bring it with you on your next visit to ISTA.

Martin Hetzer
President

This year, we opened the Moonstone Building, which houses some of our newest research groups while intensive planning for the next cluster of science buildings continues. The construction of the VISTA Science Experience Center has commenced, and we are increasingly opening our campus to the broader public, highlighting the significance of our research endeavors. Scientific entrepreneurs and deep-tech startups continue to drive transformative changes in our adjacent xista science park. Thanks to the dedication and creativity of the ISTA community, which now comprises over 1,108 members, we are breaking new ground in research and further strengthening our support systems in science management.

Georg Schneider
Managing Director

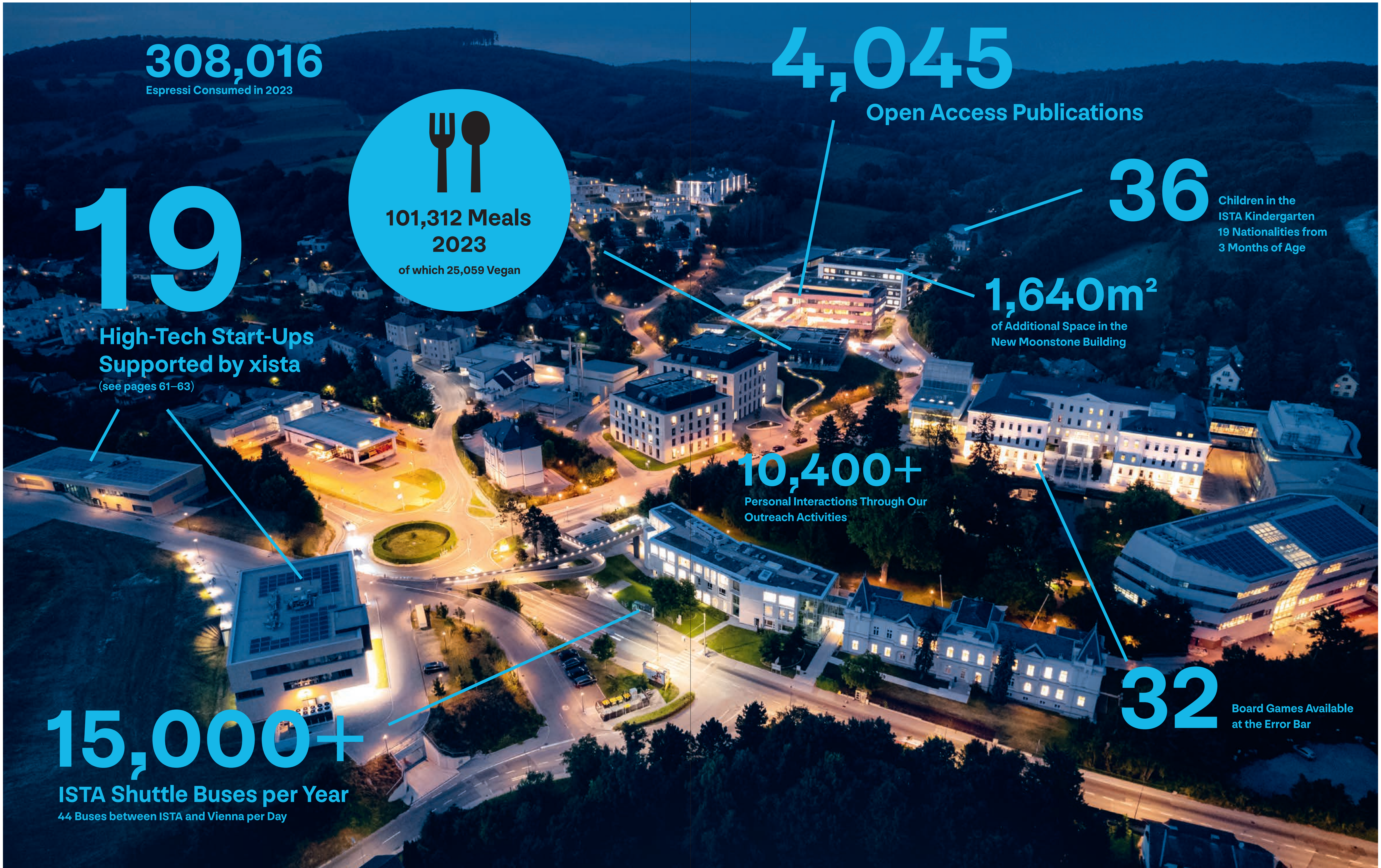
At ISTA, we engage in research through a distinctive format designed to cultivate innovation and originality. For instance, our research groups maintain a cap of 15 members, with most rotating every five years. This ensures interaction among professors, students, and postdocs. While smaller groups promote dynamism, agility, and collaborations between groups, they also present challenges. Research fields often require various highly specialized technologies. In response, ISTA has established a comprehensive base of scientific services, currently comprising 165 highly skilled and specialized employees. Though less visible than our researchers, they constitute the bedrock of our scientific success. Let us express our gratitude for their hard work and dedication!

Michael Sixt
Executive Vice President

ISTA embodies the finest aspects of science in Austria: excellent basic research, unconditional freedom of science, and interdisciplinary collaboration. I extend my heartfelt gratitude to my predecessor, Claus Raidl, whose passionate dedication to the independence of science and the Institute serves as an inspiration to me. As the new Chair of the Board of Trustees, I am committed to preserving these key success factors and upholding the autonomy of the Institute. It is equally crucial for Austria, as a hub of commerce and industry that the Institute continues to provide an optimal working environment for researchers and staff. The ongoing growth of ISTA will inevitably bring forth changes and challenges, and I eagerly look forward to supporting President Martin Hetzer and his team in mastering them successfully.

Elisabeth Engelbrechtsmüller-Strauß
Chair of the ISTA Board of Trustees

From Left to Right: Martin Hetzer, Georg Schneider, Michael Sixt, Elisabeth Engelbrechtsmüller-Strauß


308,016
Espressi Consumed in 2023
101,312 Meals
2023
of which 25,059 Vegan
4,045
Open Access Publications
19
High-Tech Start-Ups
Supported by xista
(see pages 61–63)
36
Children in the
ISTA Kindergarten
19 Nationalities from
3 Months of Age
1,640m²
of Additional Space in the
New Moonstone Building
10,400+
Personal Interactions Through Our
Outreach Activities
32
Board Games Available
at the Error Bar
15,000+
ISTA Shuttle Buses per Year
44 Buses between ISTA and Vienna per Day

Interview

Two ISTA Professors, Two Generations

As ISTA's second professor, Krishnendu Chatterjee has accompanied the Institute since its infancy. Ylva Götberg is one of the youngest additions to the ISTA faculty helping shape the newly established field of astronomy. What connects them is a pioneering spirit—in their research and in their decision to join a young and aspiring institute. Strolling through the newest building on our growing campus—the Moonstone Building—they talk about what it was like joining the Institute in 2009 and in 2023 and the excitement of starting something new.

Krishnendu Chatterjee: Welcome to ISTA, Ylva! It has only been a few months since you joined our Institute. How do you feel about your new role as one of ISTA's newest Assistant Professors?

Ylva Götberg: Thanks, Krish! I am very excited about this new experience and the chance to be one of the first astronomy faculty members at the Institute. It feels great to help build this research area at ISTA from scratch and to have the opportunity to create something novel. But most importantly, I am learning a lot. Becoming a group leader, a lecturer, and learning to lead the next generation of researchers… This is all new and very exciting to me and I have a lot to learn. Tell me about you, Krish—as one of the first faculty members to join ISTA 14 years ago, how does the Institute continue to inspire you?

Krishnendu Chatterjee: I find that ISTA provides a great academic environment for science. We have an excellent interdisciplinary atmosphere and complete freedom to pursue basic and curiosity-driven research. I can explore basic theoretical questions in computer science. Furthermore, interactions with scientists from other disciplines have inspired me to pursue research directions at the interface of computer science, game theory, and biology. For example, evolutionary game theory.

Ylva Götberg: Tell me more about your research.

Krishnendu Chatterjee: Game theory has implications for the verification of the correctness of computer hardware and software. Additionally, it has biological applications, such as evolutionary game theory. We are especially interested in the theoretical foundations of game theory. This allows us to address central questions in computer science, such as the interactive problems in decision-

Two generations of ISTA faculty meet in the courtyard of the newly opened Moonstone Building.

Left: Entering Ylva Götberg's new scientific home.

Right: A moss-covered wall and large windows facing the Vienna woods provide the right atmosphere for enlightening conversations.

making. These theoretical foundations can also be applied to study problems in logic, economics, or the design of the internet, among others. In addition, my group works on algorithmic aspects of evolutionary game theory on graphs, where the graph models a population structure. This allows us to better understand games and to develop new algorithms. This year, we published a paper in which we sought to understand the conditions leading to cooperation by developing a new game theory model (see page 46).

Ylva Götberg: And what convinced you to join ISTA in its first years when it was brand new?

Krishnendu Chatterjee: In my area of research, Europe has been the major driving force. When I joined in 2009, ISTA was starting to be shaped as an institute of basic research. It promised an interdisciplinary environment and encouragement to pursue curiosity-driven research. ISTA provided the right academic structure from the start, a tenure track system, and a flat hierarchy. Being a new institute, it had the flavor of an academic start-up. It was exciting to join the Institute in its infancy, be a part of its growing up, and contribute in whatever little way possible. What about you, Ylva? What makes ISTA, to you, an inspiring place to do science?

Ylva Götberg: I particularly enjoy contributing to shaping astrophysics research at ISTA. Helping build something new instead of finding your way through rigid and complex, decades-old structures is a rare chance. I have experienced academic environments where scientists feel enclosed within a rigid departmental structure, and I am happy that this is not the case at ISTA. I enjoy exchanging with students and scientists from diverse fields and at various career levels. The Institute provides us with a lively environment that fosters creativity and a fantastic community spirit. The sheer number of activities on campus, both scientific and non-scientific, is overwhelming! I feel that our community is bubbling with ideas and is motivated to make a change.

Krishnendu Chatterjee: Is helping to shape astrophysics research at ISTA one of the reasons that attracted you to join the Institute?

Ylva Götberg: I would even say that this was the main driver. And quite similar to how you felt about the Institute's initial growth, I do feel that astronomy is in its start-up phase at ISTA, which makes it all the more exciting to me. Together with my great colleagues Lisa Bugnet, Jorryt Matthee, and soon Ilaria Caiazzo, we have the unique opportunity to create something modern and new. We can explore inclusive and diverse approaches while also drawing on ISTA's history and experience in other, more established fields. This feeling of freedom is compelling. And we have a fantastic team to get astronomy started at ISTA!

Krishnendu Chatterjee: Which of your current research projects are you particularly excited about?

Ylva Götberg: I am especially excited about studying physical processes operating in the interiors of massive stars. This is particularly relevant in the context of massive binary stars. These are systems in which the stars would orbit around one another until the more massive star's thick, hydrogen-rich envelope expands. This expanding envelope eventually experiences a stronger gravitational pull to the companion star than to its own core, thus causing a transfer of mass, which eventually leads the entire hydrogen-rich envelope to be stripped off. This leaves the stripped star's hot and compact helium core exposed. I want to understand what sort of physical processes take place inside the stars, before, during, and after the transfer of mass. I think that the fact that the envelope is stripped off reveals the interior of the star–a region that is otherwise very difficult to study. It is a new and exciting avenue that has become available now that we have discovered the first population of such stripped stars (see page 46).

I particularly enjoy contributing to shaping astrophysics research at ISTA. Helping build something new instead of finding your way through rigid and complex, decades-old structures is a rare chance.

Ylva Götberg

Krishnendu Chatterjee: That sounds fascinating. What was it like for you to arrive on campus?

Ylva Götberg: I do feel very welcome. The onboarding process helped me to get up and running effectively. Besides, there's a sense of opportunity and flexibility that lets us feel like we can create new things without having to worry about the limits of the possible. We are in an environment that favors innovation and the leadership is very supportive of helping astronomy at ISTA grow. I also greatly enjoy the excellent scientific services and the exceptional administrative support. The overall positive atmosphere is also set by the people I interact with daily, especially the students who are putting significant effort into both their courses and projects. In addition, the fact that all professors have assistants is an incredible privilege. I want to shout out to my assistant, Dafne Valdez Lopez, who is truly the best! Tell me more about your experience with ISTA's growth—how has the community evolved?

Krishnendu Chatterjee: ISTA's growth has been tremendous. When I joined, I was the only Assistant Professor, and together with Nick Barton, we were the only two faculty members. Looking back at the years since the early days when the only two research fields we had were computer science and biology, there has been great growth in diverse areas. Each new scientific building was a major stepping stone, and with it, each new scientist helped

Left and Right: The Moonstone Seminar Center provides opportunities for international conferences.

expand and diversify the Institute. This all has shaped ISTA into the place of academic excellence we know and experience today—and we are still growing.

Ylva Götberg: Indeed, the goal is to double the Institute's size by 2036, which is already exciting and inspiring. But speaking of expansion and diversification, I feel that internationality is a core trait of ISTA.

Krishnendu Chatterjee: Yes, indeed. From having English as the language of the Institute to ensuring all incoming scientists feel welcome and keeping diversity in mind in student and post-doc fellowship selections, several efforts are made to implement and foster internationality and diversity.

Ylva Götberg: How do you inspire your group members to do exploratory science?

Krishnendu Chatterjee: That's a good question. I have always tried to discuss with the group members and identify questions and research areas that both the members and I find exciting to pursue. Once the student or postdoc is excited to investigate an idea, the rest follows easily. Do you have a certain approach that works for you?

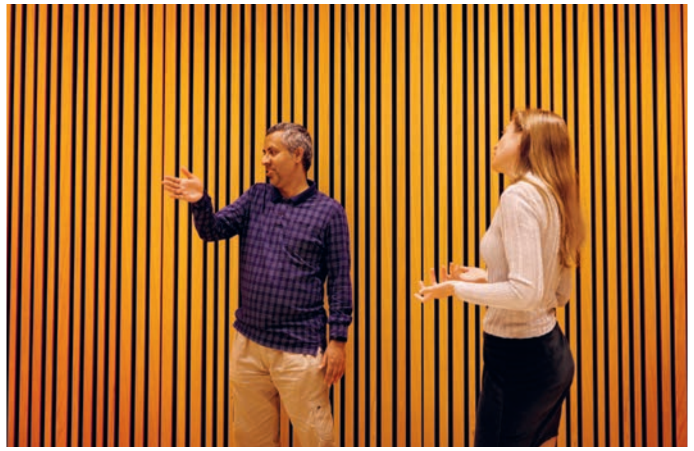
Ylva Götberg: I am myself in the process of learning. People are different, and we are all driven by different factors. I am driven by the unknown and by being at the edge of knowledge, but I know that some students are driven by technical challenges. Right now, my main goal is to show my students what being an astronomer can be like. This includes observational work in combination with simulations. I focus on establishing a positive, inspiring atmosphere and good discussions often ensue during our observations. Night observations are of course not mandatory, but very useful and inspiring to students. Also, I enjoy that my group members engage in discussions with one another, and I try to help bring structure into their exchanges. I am also learning the importance of giving my students space to discuss with my collaborators. Exploring how I am as a group leader requires flexibility and openness, and I am learning and adapting my leadership style to individual group members.

Krishnendu Chatterjee: Thank you for your insights, Ylva! You are laying strong foundations for your group and the future of astronomy at ISTA.

Ylva Götberg: Thank you, Krish, for sharing your thoughts with me. I'm taking inspiration from your experience and am excited to join ISTA on a journey of growth.

Looking back at the years since the early days when the only two research fields were computer science and biology, there has been great growth in diverse areas.

Krishnendu Chatterjee



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.

38
Average Age of all Professors upon Recruitment

Tenure Evaluation

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

Tenured Position
unlimited

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

83
(Assistant) Professors or Staff Scientists

Change of Institution

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

204
Postdocs
up to 5 years

Change of Institution

Fully Funded PhD Program

Career Steps at ISTA

345
PhD Students
4.5–6 years

PhD Qualifying Exam

Rotation within the First Year

422
Administrative and Scientific Support

Internships for Undergraduates

Professionals in a variety of administrative areas as well as experts that provide research groups with scientific and technical assistance.

Science Education & Outreach

Launching VISTA to Shape Tomorrow's Critical Minds

Curiosity and enthusiasm for questions that do not have answers yet are what unite the people working at ISTA. We want to pass on this passion and make the innovative research at the Institute accessible to everyone. The year 2023 marked many important milestones to open up the campus to the public in order to strengthen understanding of and trust in science.

Since its opening in 2009, ISTA has focused on cutting-edge research in the natural sciences, mathematics, and computer sciences. "In addition to research itself, the promotion of science to the public is already firmly anchored in the founding documents," says ISTA's Vice President for Science Education and neuroscientist Gaia Novarino. ISTA's new outreach brand, called VISTA Science Experiences, aims to transmit a deep understanding of the dynamics of science. "With VISTA, we explain how science works—that is, how results are obtained, reviewed, discussed, discarded, changed, and adapted. This way, we want to build actual understanding for science as a process—in addition to enthusiasm," Novarino explains. Instead of just presenting the results of research, the Institute wants to show how knowledge is created and thus strengthen trust in research.

Bridging science and society—the VISTA Science Experience Center

On October 20, we broke ground for the future home of the Institute's outreach activities in the middle of the campus—the VISTA Science Experience Center. "It's time for a physical place where we can welcome the population for our activities," Novarino says. The new building with around 1,500 m² will be home to, among other things, an exhibition space, an auditorium, a café, and learning and maker spaces. "We are planning a unique Research Gallery: art, science, design, and technology will meet there in fascinating collaborations between scientists and artists," Novarino adds. Of the total area of the building, around 400 m² lie above ground. Additional rooms are located underground to preserve the charm of this central space on the ISTA campus.

Breaking ground for the VISTA Science Experience Center: ISTA President Martin Hetzer, Governor of Lower Austria Johanna Mikl-Leitner, Austrian Federal Minister for Education, Science and Research Martin Polaschek, and ISTA Vice President for Science Education Gaia Novarino.

> **With VISTA we want to build actual understanding for science as a process—in addition to enthusiasm.**
>
> Gaia Novarino, Vice President for Science Education, Neuroscientist

Discovering science hands-on

ISTA has expanded its public outreach programs and created a dedicated science education team, which has grown to twelve people in 2023. And as with ISTA, all arrows at VISTA are pointing upwards. "In 2022, the team had been in contact with 500 students," says Christian Bertsch, Head of Science Education at ISTA, home to the VISTA activities. "By 2023, we had 10,000 direct audience interactions, plus 20,000 indirect interactions through teachers working with our materials. We set ourselves ambitious goals because we are convinced that an understanding of science and critical thinking are key competences in a digital knowledge society," he explains. The team's new home on campus in the newly opened Moonstone Building offers space to experience hands-on science and step into the world of research.

Breaking down clichés

In all VISTA programs, the explicit promotion of an understanding of science is central. "We make science as a process tangible and current cutting-edge research accessible—often in direct contact with researchers. This is because direct dialogue is the best way to refute traditional ideas about science. Researchers are not quirky geniuses who stand alone in the lab all day, but creative people who work with passion and in teams on the big questions of our time," Bertsch explains. Connecting science and scientists with the public is also the central idea behind the new VISTA Science Tuk Tuk, which hit the road for the first time in 2023, touring parks and street festivals with science busking activities.

Bringing science to where the people are with the new Science Tuk Tuk: Christian Bertsch, Nadine Mund, and the whole VISTA team.

Head of Science Education Christian Bertsch and ISTA Vice President for Science Education Gaia Novarino.

“The coolest school lesson”

Anyone who wants to make good decisions must be able to obtain, sort, and evaluate information. VISTA projects such as ‘FakeHunter’, which teaches young people to recognize and debunk science-related fakes on the internet, provide support in this regard. FakeHunter materials are also part of the training for teachers who teach digital literacy. “Supporting teachers is an important lever for making a big impact,” explains Bertsch. Another VISTA novelty this year was the VISTA Science Christmas Show: an interactive online show with spectacular experiments aimed at young audiences in primary and secondary schools, aired live to classrooms throughout Austria right before the holiday season. “The VISTA Science Christmas Show is perhaps the coolest school lesson before the break,” says Bertsch.

Opening up the campus

Besides these new formats, the Institute opened its doors to more than 2,000 guests at the annual Open Campus Day. At the biggest science party of the year, visitors can explore hands-on experiments at the science exhibition, peek behind the curtains during guided tours through the laboratories, and be astounded by a spectacular experimental show. Throughout August, the ISTA Summer Campus again invited 250 children and young people to the Institute to follow their curiosity and explore. Furthermore, the format 'Zoom a Scientist,' originally started during the pandemic, has continued in 2023. In a series of online meetings with young ISTA scientists from a variety of research fields, school students learn about career paths and the everyday work of scientists.

New Paths of Science Education and Outreach

Merely a few months after its launch, the VISTA team has big plans for the future. Already in 2024, the team will launch the Neuroscience Academy, its most comprehensive program for motivated high school students to date. In debate clubs on socio-scientific issues, young people from diverse backgrounds will train their reasoning and argumentation skills. Additionally, there will be a stronger involvement of many ISTA scientists who share VISTA’s vision. With the VISTA Science Experience Center to be opened in 2025, the whole team is gearing up their activities to reach and engage more people, exploring new paths to foster a society that understands, trusts, and ultimately celebrates science.

“Researchers are not quirky geniuses who stand alone in the lab all day, but creative people who work with passion and in teams on the big questions of our time.”

Christian Bertsch, Head of Science Education

ISTA Launches Two Residency Programs

Starting in 2023, the Institute offers creative professionals the opportunity to intensively engage with its scientists to gain inspiring insights into state-of-the-art research, exchange ideas, and work on their own exciting projects. The first four residents share what inspired them and what they took away from this experience.

Jackson W. Ryan
Journalist in Residence

Mark Belan
Journalist in Residence

Daniela Brill Estrada
Artist in Residence

Shailesh BR
Artist in Residence

Jackson W. Ryan
The Australian science journalist was the inaugural journalist in residence at ISTA. During his stay, he presented various workshops sharing his experience in the digital science journalism landscape and teaching researchers how to tell their science stories to the world. "The program presents the opportunity for journalists to step away from the daily grind and focus on big-picture thinking. For me, that meant trying to understand how we can work together to ensure the public understands the importance of the scientific process and the search for truth in a world filled with uncertainty."

Mark Belan
During his time at ISTA, the Canadian scientific illustrator and visual communications expert was working alongside the Kicheva and Heisenberg groups and their embryological studies, and further expanded into the realms of asteroseismology, social immunity, and quantum physics. "I was extremely fortunate to immerse myself at ISTA's campus and experience first-hand the exciting research being conducted there. It gave me the opportunity to expand both my knowledge and network in these spaces. By giving talks and workshops, and creating custom graphics, I was also able to give back to the community."

Daniela Brill Estrada
"How are astrophysics, molecular biology, and artificial intelligence related through our sensed experience of the world, and what does aesthetics have to do with this? How can aesthetics and artful research enrich and strengthen scientific knowledge?" It is questions like these that the Colombian artist is excited to talk about, discuss, and maybe rethink the importance of aesthetics in scientific investigations. With her installation, Brill Estrada looked at the boundaries of materiality and information and at which points we consider matter to display life-like behavior, or not.

Shailesh BR
Raised in a small village in India and formerly trained as a monk, Shailesh BR brought together the origins of Indian filmmaking, histologic microscopy, and scientific observation during his residency. "Technology and Science are dominant parts of our lifestyle now, whether we choose it or not, making me more curious to know in depth about technology. It is almost like magic, but it is factual and achievable with research and accuracy. This tempts me to use it as both a medium and a subject in my practice."

Sculpture of an experiment by Shailesh BR from his project "Birth of a Pea Plant"

Self-drawing carbon spheres from Daniela Brill Estrada's project.

PhD Students

Spark a (Research) Flame

Each year, graduate students from around the world embark on an exciting journey at ISTA. The unique features of the PhD program—such as rotations, interdisciplinary coursework, and excellent support for pioneering research—provide the perfect environment for budding scientists to flourish during their time on campus and beyond.

On a sunny afternoon in June, a buzz of celebration sweeps across campus. A crowd of mortarboards gathers at the steps leading up to the Central Building. It is graduation day, an unforgettable moment for the 29 bright minds celebrating their recently completed doctoral and master's degrees at ISTA. After speeches by ISTA President Martin Hetzer, honorary speaker Jan Konvalinka from IOCB Prague, and Dean of the Graduate School Eva Benková, the graduates receive their certificates and are charged with the task of writing the next chapters of their careers. Saying goodbye to the graduates coincides with welcoming a new cohort of doctoral students. Each September, ISTA opens its doors to a new group of highly qualified bachelor's and master's degree holders—an annual renewal and expansion of inquisitive, promising young scientists. "ISTA's PhD program aims to develop versatile, curious scientists who can tackle problems from different perspectives," explains Benková. "Our students are guided by a world-class faculty and undergo an interdisciplinary education that combines research and teaching elements."

Across disciplinary boundaries

This year, 66 new PhD students from five continents began their scientific journey. After an orientation period, the students are divided into seven general research areas (or "tracks") and begin their rotations, during which they spend up to two months each in at least three different research groups at the Institute. This rotation phase is a novel concept in Austrian higher education. It promotes scientific exchange across disciplinary boundaries. It also encourages PhD candidates to get acquainted with a broader spectrum of research conducted at ISTA. In addition to rotations, ISTA PhD students also complete cross-disciplinary coursework. This includes mandatory coursework in which students discuss scientific topics and publications with colleagues from other tracks, as well as track-specific seminars that provide the building blocks needed for a particular area of research. "Depending on their interests and fit, students then join one or two groups," explains Maria Trofimova, Head of the Graduate School Office. "It's a milestone in their studies, after which they turn to their research project as a full-time group member." As they conduct their research, graduate students benefit from the collective wisdom of ISTA faculty, postdoctoral fellows, research technicians, Scientific Service Units (SSUs; see pages 56–60), staff scientists (see pages 98–101), and their immediate peers in the graduate school. Shared knowledge, supported by state-of-the-art equipment, enables students to thrive during their time on campus. PhD Award recipients Rishabh Sahu and Morris Brooks exemplify what a successful PhD can mean. Sahu's research is fundamental to the field of quantum physics and resulted in one of ISTA's 2023 Research Highlights (see page 50), while Morris' work on quantum systems could have been the subject of three separate dissertations. In addition to immersing themselves in their dissertation research, students attend international conferences and colloquia, and receive additional training in teaching and various transferable skills. While at ISTA, all students earn a an attractive salary, pay no tuition fees, and receive full benefits.

PhD Award recipients, Rishabh Sahu (left) and Morris Brooks (right).

From undergraduate to PhD

Typically, earning a PhD takes between four and a half and six years to complete, as each student is at a different starting point when they arrive on campus. While some have a master's degree, others come directly from a bachelor's degree. In this respect, ISTA's PhD program is unique. Starting in 2021, the Institute allows recent bachelor's graduates to earn a master's degree on their way to a PhD. Bachelor's degree holders must complete additional elective courses and fulfill extracurricular requirements as they progress toward their PhD. For Roksalana Kobylinska, a first-year doctoral student, this was a deciding factor in coming to Klosterneuburg. "Discovering that I could jump into a PhD program right after my bachelor's degree made ISTA a perfect fit for me," she says. ISTA also offers research internships. "There are two different ways to become an intern: The ISTernship summer program, with a centralized application and admission process, and year-round scientific internships, where interns are hired directly by principal investigators," Trofimova explains. For some graduate students, these internships were their first contact with the ISTA campus community.

Student life at ISTA

Sometimes the best inspiration comes from outside the lab. ISTA offers many opportunities for extracurricular activities that promote a healthy work-life balance. Students can take advantage of ISTA's sports facilities or join social groups, including the Photography Club, ISTA's Sustainability Group, and many others. Social activities help students make new friends and get to know the Institute's international and vibrant community. Students can also take advantage of on-campus housing. Single graduate students or interns, as well as couples and families, are welcome to live in on-campus apartments. For those who enjoy urban life and activities, the ISTA Shuttle offers a short ride to Vienna—repeatedly voted the world's most livable city.

A bright future ahead

Whether this year's graduates pursue careers in academia, as corporate leaders, or as out-of-the-box innovators in industrial research and development, the Institute's excellent education sets the tone for a bright future. Wherever their careers may take them, ISTA's alumni network (see page 34) remains a faithful companion, keeping them in touch with their alma mater.

A Glimpse into PhD Life

PhD students Christine Fiedler and Lukas Lindorfer discuss their research, how to find the ideal thesis projects, and offer insight into ISTA's opportunities to excel in their careers.

ISTA students celebrate their graduation ceremony.

Christine Fiedler
4th-year PhD student
in the Ibáñez group.

Lukas Lindorfer
3rd-year PhD student
in the Cremer group.

What is your PhD project about?
I'm working on thermoelectric materials that can convert heat into electricity and vice versa. It's a technology that promises to unlock new frontiers in energy generation, transportation, and even the fashion industry. It has the potential to create a world where heat is no longer a waste product but a valuable resource, leading to a more sustainable future. In the lab, I focus on producing thermoelectric materials via solution methods. However, tuning thermoelectric properties is like walking a tightrope—you have to balance the conductivity and thermal resistance to maximize energy efficiency. It is a matter of finding the sweet spot where materials perform their energy-conversion dance with precision. It is a fine art to optimize for peak performance without sacrificing stability.

What was your path to ISTA and what facilitated your growth as a scientists?
I was born and raised in Barbados, but I am also Austrian. After completing my bachelor's in chemistry and biochemistry in Barbados, I did my master's degree in Austria. Given my personal attachment to Austria, my former supervisor recommended that I should apply for the PhD program at ISTA, as she had heard about the work of my current supervisor, Maria Ibáñez, and thought that it would be a great opportunity for me. What helps me in my PhD journey is the vast amount of support and resources that are available to me. There are several things I enjoy, for instance, the mentorship I receive from my group leader and postdocs, the opportunity to travel to other countries for conferences, the availability of equipment, and, of course, the possibility to collaborate with numerous colleagues on campus.

How did you find the ideal fit for your PhD project?
My PhD studies deviate strongly from the subjects of my bachelor studies. The initial rotation phase of the PhD program allowed me to explore different fields to find my perfect match. During this time, I discovered my passion for evolutionary biology and then affiliated with Sylvia Cremer's group, which focuses on social immunity in ants. These social insects have remarkable ways of fighting epidemics in their nests through grooming, altering interactions, and even self-sacrifice. Currently, I am studying their nest disinfection process in real-time. Ants spray their nests with an acidic poison that we think acts like a disinfectant. By introducing contamination, we can test how effective this spraying is at neutralizing the contamination. Frankly, I would never have tried this area of research if I had not been given the opportunity here at ISTA.

What led you to ISTA and what has your experience been like so far?
I used to work as an elementary pedagogue in a kindergarten. However, at the age of 22, my curiosity led me to study biology, and I obtained a bachelor's degree. You could say that working in the kindergarten led me to the place where I would go on to do my PhD. I found ISTA through a parent of a child in my group who happened to be a postdoc here. The Institute's outstanding facilities, collaborative atmosphere, and interdisciplinary nature allowed me to pursue my research interests and broaden my horizons by exploring areas in which I had no prior experience. In addition, since students from all study tracks start in the same cohort, you can make friends who become experts in fields as diverse as NMR spectroscopy, epigenetics, and plant hormones. This improves the flow of useful information during coffee breaks.

Postdoctoral Researchers

Exploring Uncharted Territories

Embarking on a postdoctoral journey marks a critical juncture for recent PhD graduates. ISTA recognizes this moment and wants to encourage ambitious researchers to follow their curiosity even if it means taking risks. From fostering interdisciplinary research to creating flexible career paths beyond academia, ISTA offers a variety of fellowships to support postdocs exploring new realms of research.

After their PhD, scientists are at a pivotal point in their careers. Many enter a postdoctoral research phase, wherein they progress toward becoming leading scientists in their respective fields. However, to conduct cutting-edge research, a postdoc requires the right environment and resources. "ISTA's postdoctoral programs give early-career scientists the chance to grow professionally, as they can solely focus on doing fundamental research at the highest possible level," explains Glen Dalton from the Postdoctoral Office at ISTA. Through the Institute's state-of-the-art facilities, career development training, and workshops, postdocs can immerse themselves in the interdisciplinary working atmosphere. ISTA's postdocs interact with colleagues via joint projects, seminars, or leisure activities—an image underscored by the collaborative, cross-disciplinary publications published this year (see pages 42–55).

NOMIS Fellowship: Embarking on unknown terrain

For researchers who want to tackle big questions that require tools and expertise from multiple fields, the NOMIS Fellowship may be the perfect fit. Four years ago, ISTA partnered with the Zurich-based NOMIS Foundation to create a unique fellowship program. In 2023, this collaboration has become vital, with seven outstanding fellows advancing innovative, high-risk research that holds potential for groundbreaking discoveries. In line with the shared commitments of NOMIS and ISTA, these fellows can pursue a postdoc at the intersection of multiple scientific disciplines. NOMIS fellows become trailblazers, trying to connect the familiar with the unexpected and set the foundation for their distinctive research topics. As they forge into new terrain, they may face challenges due to their project's complexity and unpredictable outcomes. ISTA is committed to supporting them on their path with a three-year fellowship and the opportunity to be

Postdocs Ekaterina Krasnopeeva and Roderich Römhild from the Guet group.

co-supervised by two different group leaders at ISTA. External secondary supervisors may also be consulted, as fellows can spend up to three months at an external research facility. Louise Fouqueau for example, is using theoretical biology approaches in Nick Barton's group and data analysis in Yvonne Willi's lab at the University of Basel to investigate the evolution of self-fertilization in the lyre-leaved rock cress and its consequences for adaptive potential. Additionally, NOMIS fellows also benefit from training in scientific integrity and leadership, as well as career development support.

Tailored career development
Postdocs with passions outside of pure research are in good hands in the IST-BRIDGE program. Launched in 2021, it offers a two-year, fully funded postdoctoral fellowship with tailored career development. "Whether in academia, industry, policy, or another field, the BRIDGE career track structure provides support and training for fellows to pursue their desired careers," says Dalton. In November 2023, the fifth and final call ended with 154 applications. Seventeen new IST-BRIDGE fellows will start their journey at ISTA in 2024. They can choose from courses categorized by different career tracks, like academic leadership, science outreach, entrepreneurship and industry, as well as research and innovation. Through academic secondments, fellows can explore research groups in one of the excellent institutions of the BRIDGE network, including 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. There are also opportunities to discover non-academic environments, either externally or internally such as ISTA's Scientific Support Units or the newly launched xista innovation ecosystem (see page 61).

The Many Faces of Physics

IST-BRIDGE fellow Maitane Muñoz-Basagoiti and NOMIS fellow David Brückner discuss their respective fellowship programs and the use of physics to address fundamental questions in biology.

Shining like the ISTA graduates' careers: cells in a petri dish.

David Brückner
NOMIS fellow in the Hannezo and the Tkačik groups.

What is your research about?
In general, theoretical biophysicists like me look at biological systems from a different perspective. We use theoretical physics principles and methods to understand complex living systems that are traditionally outside the realm of physics. Collaboration with experimentalists is crucial to our research. We are often confronted with puzzling experimental data that needs to be interpreted. Theoretical physics helps us identify patterns in the data and generate hypotheses that guide us to build predictive models. These models can then be tested experimentally, helping us to refine our models. At ISTA, my research focuses on how biological systems use interactions between mechanical and biochemical processes to generate patterns and shapes in embryonic development.

What stands out in your specific fellowship?
After graduating from LMU Munich, I was looking for a research program that would allow me to transcend the boundaries of physics and biology. The NOMIS fellowship's and ISTA's hallmarks of interdisciplinary and curiosity-driven research proved to be a perfect fit for me. ISTA helped me establish collaborations with a wide variety of research groups, connecting my work on mechanical models of tissues (Hannezo group) and information theory (Tkačik group) to experiments on stem cell assemblies (Kicheva group) and the mechanics in zebrafish embryos (Heisenberg group). Being part of the NOMIS fellowship program gave me the freedom to explore these different directions with a high level of independence.

Maitane Muñoz-Basagoiti
IST-BRIDGE fellow in the Šarić group.

How are symbiosis, membrane morphology, and evolution connected?
This is precisely the question I am trying to answer through my research at ISTA. Currently, I am developing a coarse-grained computational model to study how symbiosis—the beneficial coexistence of two different species—affects the shape of cell membranes. Finding out more about this topic is essential to understanding how eukaryotic cells, like those in our bodies, with complex structures such as the nucleus and mitochondria, first emerged. Existing theories suggest that eukaryotes evolved when two prokaryotic cells—an archaeon and a bacterium—lived together in symbiosis. Nevertheless, the physical mechanisms underlying such a process are poorly understood. My project aims to understand these mechanisms and shed new light on symbiosis as an evolutionary driver.

What stands out in your specific fellowship?
My background is in physics, but I have always been interested in interdisciplinary research. After my PhD at ESPCI in Paris, I wanted to delve even deeper into different scientific strands. In this regard, the IST-BRIDGE fellowship allows me to pursue an exciting research project at the frontier between physics, biology, and computer science. ISTA is a great place for collaborations across disciplines, and I really like interacting with other groups on campus. In addition, the Institute offers a dynamic working atmosphere, with scientists from all over the world visiting to give seminars on an almost weekly basis.

NOMIS FOUNDATION Creating the Spark | FELLOWS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101034413.
The NOMIS-ISTA Fellowship program is supported by the NOMIS Foundation.

Alumni

A Growing Global Network

As ISTA graduates and postdocs move on to new horizons around the globe, they join the ranks of professors, lead research groups, start companies, or go on their individual paths to success. In less than 15 years, the global network of ISTA alumni has grown to include respected scientists, corporate leaders, and out-of-the-box innovators in industrial research and development. ISTA is committed to maintaining an active connection with and nurturing this growing network of bright minds.

ISTA alumni are global ambassadors of the pioneering spirit of the Institute and its researchers. Many are engaged in academic pursuits, including those who have secured faculty positions at renowned universities and research centers. Furthermore, numerous alumni have chosen to transition into roles in business and industry. This year, we share the stories of three alumni who have built on their experience at ISTA and made an impact in their diverse fields.

Embryogenesis: Patterns and shapes in development
Among the ISTA alumni who have contributed to growing the Institute's global network is cell and developmental biologist Diana Pinheiro. After her PhD at the Institut Curie in France, where she researched cellular and tissue morphogenesis in *Drosophila* pupae, Pinheiro joined ISTA's Heisenberg group as a postdoc in 2017. There she switched from flies to fish and investigated the development of zebrafish embryos. In 2022, she started her own research group at the Research Institute of Molecular Pathology (IMP), a part of the Vienna BioCenter, and received an ERC Starting Grant in 2023. "For a cell to fulfill its function it doesn't just need to differentiate, it also needs to be at the right place. My lab will explore how a relatively small set of highly conserved developmental signals is able to encode all this complex information—patterning and morphogenesis—to coordinate embryogenesis across scales," said Pinheiro upon starting her group.

Giving physics a hand – through mathematics
Another ISTA alumna who has embarked on a career in academia at a world-renowned institution is mathematical physicist Simone Rademacher. In 2019, Rademacher joined the Seiringer group at ISTA as an ISTplus postdoctoral fellow after completing her PhD at the University of Zurich, Switzerland, where she studied the mathematical properties of many-body quantum systems. In 2022, she joined the Mathematical Institute of the LMU Munich in Germany as a deputy professor in the Stochastics and Financial Mathematics research group. "I am interested in the mathematical analysis of both many-body quantum systems, such as bosonic and fermionic systems and the polaron, and their effective equations. On the one hand, I study the mathematical description of Bose-Einstein condensates using central limit theorems and large deviation principles. On the other hand, I am working on the properties of the effective equations for polaron models and their derivation from the many-body quantum systems," says Rademacher.

An ISTA Alumni Award recipient at Google Research
What the future can hold for excellent PhD students after graduating from ISTA is shown by the example of Alexander Kolesnikov: He received his PhD in 2018, is currently working at Google Research in Zurich, Switzerland, and received this year's ISTA Alumni Award, which is given to outstanding former ISTA researchers. During his PhD in the Lampert group, Kolesnikov focused on designing computer systems that can automatically learn to analyze and understand visual information, such as images or videos. "The crux of my research is to improve the efficiency with which computers learn to interpret visual data from examples," Kolesnikov explains. Having become a highly cited scientist in his field in less than five years after completing his PhD, Kolesnikov's achievements have been duly recognized. "The ISTA Alumni Award recognition has a special meaning for me", said Kolesnikov, "because ISTA has played a pivotal role in shaping me as a scientist."

Diana Pinheiro: Former Heisenberg group postdoc; Group leader, IMP, Vienna BioCenter

Simone Rademacher: Former Seiringer group postdoc; Deputy Professor, LMU Munich

Alexander Kolesnikov: Former Lampert group PhD student; Scholar at Google Research

Unbounded Curiosity

The researchers at ISTA follow their curiosity into the smallest details of life as well as to unimaginable magnitudes. In doing so, they discover interesting answers and encounter numerous new questions.

425

Publications in 2023

10^{-15}
How do you translate quantum information?
Fink Group
see page 47

10^{-8}–10^{-9}
How does DNA rearrange in real-time?
Brückner
see page 55

10^{-6}
How can bacteria help to create new materials?
Palacci, Hannezo, and Šarić Groups
see page 54

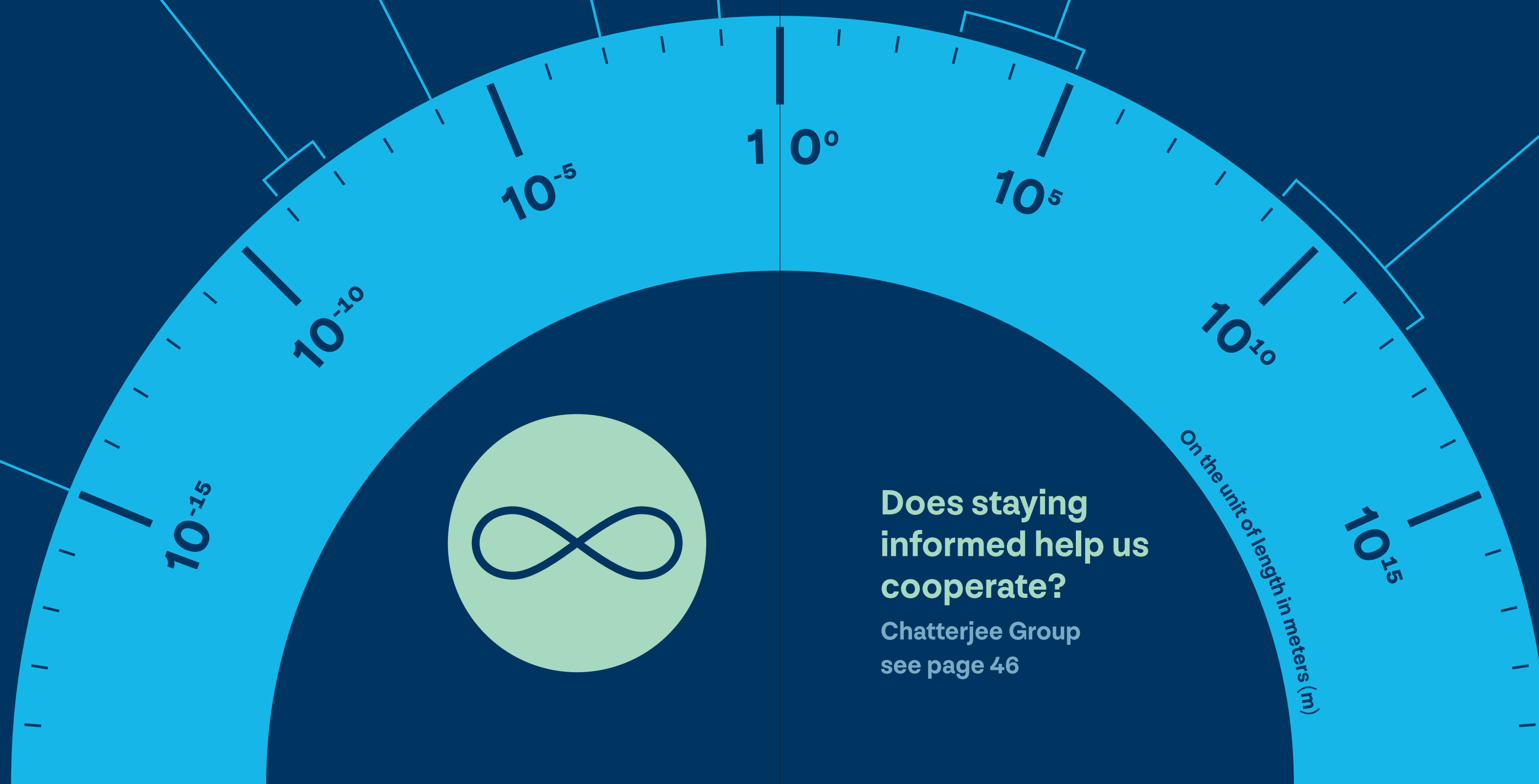
10^{-3}
Can fungi outsmart ants?
Cremer Group
see page 51

10^{-1}
What can the heart teach us about efficient pumping?
Hof Group
see page 43

10^{3}–10^{5}
How do glaciers react to climate change?
Pellicciotti Group
see page 50

10^{9}–10^{12}
How do you find a missing star population?
Götberg Group
see page 46

10^{21}–10^{26}
How do galaxies form in the distant universe?
Matthee Group
see page 44



Does staying informed help us cooperate?
Chatterjee Group
see page 46

- Mathematical & Physical Sciences
- Information & System Sciences
- Life Sciences

Science & Research

Opening Up New Horizons

What remains concealed in the dark? What is hidden from our sight? What insights and, furthermore, what additional questions are just waiting to be explored? It is the fascination with the unknown that drives the people at ISTA, inspiring them to excel in their research endeavors.

New paths were taken in numerous research areas this year. The field of astrophysics was only established on campus in 2023, welcoming three new members of faculty. With them, research at the Institute is now taking place on a new scale. We are looking far beyond the horizon, to the galaxies of the first generation at the beginning of the universe, to the evolution of stars, and the physical processes within them. Yet, fueled by curiosity, we also navigate the microcosm, uncovering entire worlds within the intricacies of ant immunity, the neural networks of our brains, the motion of DNA within cell nuclei, and even the entanglement of disparate photons that helps lay the foundation for future quantum computers. From the very beginning of their careers at ISTA, researchers are encouraged to leave the boundaries of their disciplines behind and venture into new territory by cooperating with and supporting each other across research fields.

The research projects on the following pages exemplify the Institute's pioneering spirit.

I am fascinated by the excitement on campus to break new ground.

Rafal Klajn
Professor

Bartholomäus Pieber
Assistant Professor

The Power of Light

Since 2023, two new group leaders have been shedding light on the unknown. Rafal Klajn and Bartholomäus Pieber both harness light to control chemical reactions and self-assembly processes. Together with his team, Klajn has developed a way to “switch” simple molecules with visible light, thus converting the energy of light into chemical energy. In doing so, they rely, much like nature, on confining the molecules within nanosized cavities. The Pieber group is also inspired by nature, where sunlight provides the energy for the construction of complex molecules from water and carbon dioxide during photosynthesis. Pieber aims to use visible light as a waste-free and renewable energy source, developing methods that one day could be used to activate drugs at just the right location in the body using light. Alongside their established colleagues, the two new groups are taking chemistry on campus to enlightening new heights.

Chemistry

Klajn and Pieber groups

Cell Biology

Migrating immune cells.

Sixt and Hannezo Groups
Immune Cells Shape Their Path

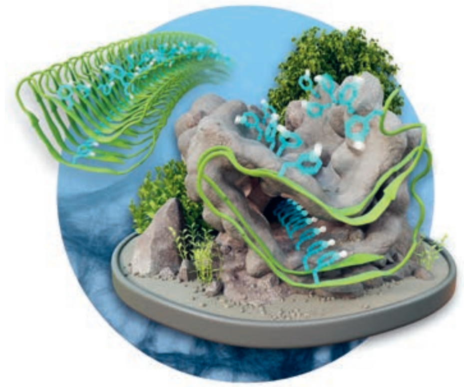
A joint effort by ISTA scientists shows that immune cells migrate along self-generated gradients.

Immunologic threats like germs or toxins can arise everywhere inside the human body. Luckily, the immune system—our very own protective shield—has its own intricate ways of coping with these threats. In a study published in *Science Immunology*, scientists from the Sixt and Hannezo groups explored how immune cells collectively navigate through complex environments and discovered an unexpected aspect in their movement.

Through different experimental techniques, the researchers found out that dendritic cells, crucial in our body's immune defense, use a receptor called CCR7 not just to detect chemokines—small signaling proteins—but also to shape their surroundings by absorbing those signals. This dual function allows immune cells to generate gradients of guidance cues to orchestrate their collective migration more effectively. Subsequent computer simulations validated these observations and predicted that the dendritic cells' movement depends on their responses to the chemokine and on the density of the cell population.

The findings have significant implications for our understanding of how immune responses are coordinated within the body. By uncovering these mechanisms, scientists could potentially design new strategies to enhance immune cell recruitment to specific sites, such as tumor cells or areas of infection.

Chemistry
Biochemistry



Rock-solid amyloid: amyloid fibrils have a rigid core and a highly flexible outside.

Schanda Group
When NMR Meets Biochemistry

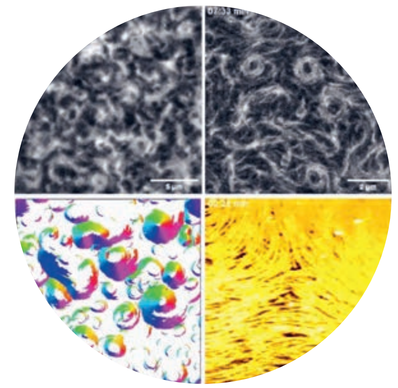
The Schanda group uses nuclear magnetic resonance (NMR) spectroscopy to decode protein dynamics.

Proteins are long molecules made from chains of amino acids, and are responsible for almost everything that a biological cell does, which eventually allows life to unfold: they perform chemical reactions, convert light in our eyes to electrical signals, and many more things.

The correct execution of these processes is crucial for the functioning of a cell. The Schanda group studies the motions of enzymes, like proteins that act as catalysts of chemical reactions in the cell. "We want to understand how evolution has shaped not only the three-dimensional structures of proteins but also how millions of years of evolution have optimized the motions of these 'molecular machines'," Schanda explains. Moreover, they also investigate proteins that assemble into a different architecture than they should, for example, when they form deposits in the brain of Alzheimer's patients known as amyloid fibrils—long filamentous structures with immense importance for neurological pathologies.

In a recent study, the Schanda group investigated motions in amyloid fibrils using so-called NMR spectroscopy. "NMR allows us to see the movements of individual atoms or amino-acid side chains within a 3D structure," Schanda continues. The results, published in *Angewandte Chemie*, present an unprecedented look into the fibril structure and show that they are formed by a very rigid core and rapidly moving side chains on the outside.

Cell Biology
Biochemistry
Physics



Combining different microscopy techniques and simulations to show how active filaments self-organize.

Loose, Hannezo, and Danzl Groups
Seeing Active Filaments Self-Organize

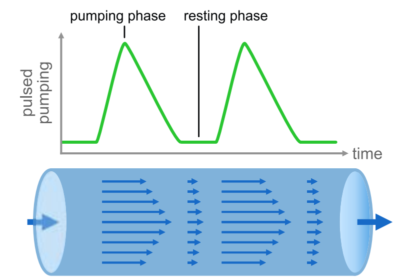
Researchers from the Loose and Hannezo groups team up to uncover how filaments of a protein important for bacterial cell division self-organize into large-scale structures. The international collaboration includes ISTA's Danzl group and researchers in Europe and Japan, allowing the team to connect theory with biology and better understand how bacteria divide.

In this study, co-first authored by Zuzana Dunajová, PhD student in the Hannezo group, and Batirtze Prats Mateu, alumna of the Loose group, the ISTA researchers unravel how the physical properties of active filaments influence their large-scale collective organization. Combining computational and biophysical approaches, they demonstrate how factors like flexibility, density, and chirality affect filaments behavior.

"Previously, we could not 'see' individual FtsZ filaments at high densities," says Martin Loose. "Now, using High-Speed Atomic Force Microscopy (HS-AFM), we have been able to observe individual, dynamic filaments in action at various densities." The findings allow the researchers to link theory and biology, and explore the fundamental properties of self-organizing, active biological systems.

"With this collaboration, we are now able to understand how the mechanics and chirality of active filaments determine their density-dependent collective transitions," says Edouard Hannezo. The findings shed light on how these filaments come together to form the cytoskeletal structure that allows bacteria to split into two.

Physics



Pulsed pumping gets rid of turbulence. This pumping motion is inspired by the pulse shape of the human heart.

Hof Group
Pumping Like the Heart

Pumping liquids may seem like a solved problem but optimizing the process is still an area of active research. Any pumping application—from industrial scales to heating systems at home—would benefit from a reduction in energy demands.

Now, a team of researchers around Davide Scarselli and Björn Hof at ISTA demonstrated how to reduce both friction and energy consumption due to pumping. For this, they took inspiration from a pumping system intimately familiar to everyone: the human heart.

Nearly twenty percent of global electric power is used for pumping liquids around—ranging from industrial applications to heating installations in private homes. The ISTA team looked for a way to reduce these energy demands, taking inspiration from nature. They showed that pumping liquids through a pipe in pulses—much like the human heart pumps blood—can reduce friction and save energy.

"Over the years, researchers and engineers have been trying to make pumping fluids more efficient," says Scarselli. "However, solutions being simulated or tested in labs are often too complex and therefore too costly to be implemented in real industrial applications." While the researchers demonstrated promising results, real-world applications of their findings are less straightforward.

"Pumps would have to be refitted to produce these pulsating motions. However, this would still be much less costly than modifications to the pipe walls or the fitting of actuators," says Scarselli.

Stargazing Wonders

As of this year, ISTA is reaching for the stars: together with their respective teams, Lisa Bugnet, Jorryt Matthee, and Ylva Götberg have broken new ground and introduced astrophysics at the Institute. While the Bugnet group applies asteroseismology to study the magnetic fields of stars to develop a better understanding of their age and evolution, the Matthee group uses large telescopes in Chile and in space to observe galaxies and their surroundings during the first three billion years of cosmic history. Götberg's group focuses on pairs of stars orbiting around each other, thus allowing a deep look inside. At ISTA, the three group leaders not only broaden the horizon of science, but also want to build bridges across the various fields of research in the spirit of the Institute.

Astrophysics

Bugnet, Götberg, and Matthee groups

Astronomy
Physics

Visualization of a binary star undergoing mass transfer.

Götberg Group
Reaching for the (Invisible) Stars

Can you imagine stellar explosions as bright as an entire galaxy? Such supernovae have fascinated us since time immemorial. But there are more hydrogen-poor supernovae than astrophysicists can explain. ISTA astrophysicists have played a key role in identifying the missing population of progenitor stars causing these explosions.

Some stars do not simply die. They explode in a stellar blast that can outshine entire galaxies. These cosmic phenomena, called supernovae, eject light, elements, energy, and radiation into space. They also send out galactic shock waves that can compress gas clouds and create new stars. Among them, hydrogen-poor supernovae from exploding massive stars have long puzzled astrophysicists.

"There are many more hydrogen-poor supernovae than our current models can explain," says ISTA Assistant Professor Ylva Götberg. "Either we can't detect the stars that mature in this way, or we must revise our entire models." She pioneered this work together with Maria Drout, an associate faculty member of the Dunlap Institute for Astronomy & Astrophysics at the University of Toronto, Canada.

"Individual stars would typically explode as hydrogen-rich supernovae. The fact that they are hydrogen-poor indicates that the progenitor star must have lost its thick hydrogen-rich envelope," says Götberg. Now, Götberg and Drout have joined forces to hunt for the missing stars. They document a first-of-its-kind star population that finally sheds light on the origin of hydrogen-poor supernovae.

Computer Science

Access to information helps us cooperate.

Chatterjee Group
Does Staying Informed Help Us Cooperate?

The Chatterjee group's new game theory model reveals that the availability of information is linked to cooperation.

In the face of existential dilemmas, including the consequences of inequality or climate change, it is crucial to understand the conditions leading to cooperation. Scientists from the Chatterjee group therefore use games as models for real life. Their recently developed framework, published in *Nature Communications,* is based on stochastic games, combining elegant algebra and computer simulations. It sheds light on how information affects cooperative outcomes.

The researchers present a new model of games where a group's environment changes based on the actions of group members, who do not necessarily have all relevant information about their environment. Their findings suggest that there are rich interactions between the availability of information and cooperative behavior.

"Counter-intuitively, there are instances where ignorance can be beneficial for cooperation too," explains Krishnendu Chatterjee. For instance, when people know a lot, they come up with nuanced strategies. These plans, however, can be less effective at sustaining cooperation. In such a case, there is indeed a small benefit of ignorance towards cooperation.

Although it answers many questions, the new framework also opens up many new research directions. The next steps will be to include the role of asymmetric information, where one player might know the exact game being played, but another may not.

Physics

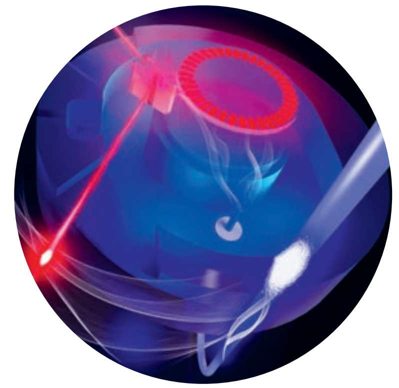


Illustration of the experimental setup showing the entangled optical (red) and microwave (blue-white) photons propagating away from the ultracold nonlinear crystal (disk) in which they were entangled.

Fink Group
Wiring Quantum Circuits with Light

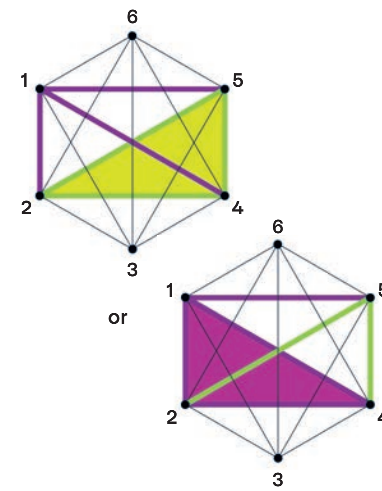
The number of quantum bits in superconducting quantum computers has grown rapidly, but further growth is limited by the need for ultracold operating temperatures. For the first time, ISTA researchers have entangled low-energy microwaves with high-energy optical photons. This advance could lay the groundwork for future quantum technologies via room-temperature links.

Superconducting processors are advancing rapidly, with current qubit counts in the hundreds. The advantages of this technology are the high computational speed and its compatibility with microchip fabrication, but the need for ultracold temperatures ultimately limits the processor size and prevents physical access once it is cooled down. This puts a limitation on the future development of quantum computers, which will likely require millions of high-quality qubits to solve challenging problems in materials science and cryptography.

A modular quantum computer with multiple separately cooled processor nodes could be the solution. However, single microwave photons are not suitable for transmission between the processors at room temperature. Thermal noise easily disturbs the microwave photons and their fragile quantum properties, such as entanglement.

Now, researchers from the Fink group have helped overcome these challenges. They entangled low-energy microwave with high-energy optical photons for the first time. This lays the foundation for wiring up superconducting quantum computers via room-temperature links.

Mathematics



An example of Ramsey's theorem: in a set of six people, you can always find a subset of three people who are either all friends or all strangers to one another (green or magenta triangles).

Kwan Group
Answering a Conjecture about Parties

Ramsey's theorem, which could be called the "party theorem," states that large systems must always have homogeneous or uniform subsystems. A conjecture aimed at understanding the structural aspects of this theorem, for which Paul Erdős notably attached a cash prize, has now been answered by ISTA mathematicians.

Ramsey's theorem has often been explained using the analogy of finding friends or strangers in a crowd. Therefore, it could be called the "party theorem." The theorem was proved in 1935 by the prominent mathematician Paul Erdős. "It remains one of the most important results in discrete mathematics," says ISTA Assistant Professor Matthew Kwan.

Since then, considerable effort has been devoted to understanding the quantitative aspects of Ramsey's theorem. Erdős famously proved that for any number n, there exist extremely disordered networks that have n nodes but no homogeneous subset much larger than log(n). However, his proof was not constructive, and we do not know of an explicit way to describe these disordered networks, now called "Ramsey graphs."

Erdős and his collaborators were very interested in Ramsey graphs and made a sequence of conjectures about them. Now, the Kwan group has solved the Erdős-McKay conjecture, the only one remaining. It states that all Ramsey graphs must have a certain property called subgraph richness. "In other words, for basically any number x, there must always be a subset of nodes with exactly x links between them," says Kwan.

Modelling Climate Change

Models are at the heart of the Institute's earth science groups. With their help, the research group of Francesca Pellicciotti is unveiling the relationships between earth's climate and surface features. Specifically, understanding the interplay of a changing climate with glaciers, snow, and water supplies is what drives the scientific curiosity of PhD student Vinisha Varghese and her colleagues. To collect data, the researchers rely not only on satellites but also travel to remote locations to observe the glaciers' properties. As a member of Caroline Muller's research group, postdoc Bidyut Goswami is particularly interested in the organization of clouds and the dynamics and thermodynamics of the tropical climate. With a better understanding of the underlying physical processes of cloud formation, the Muller group aims to improve current model projections of climate change.

Earth Science

Pellicciotti and Muller groups

Earth Science
Climate Science

The Pyramid Observatory at night, Pumori Peak (Nepal) in the background.

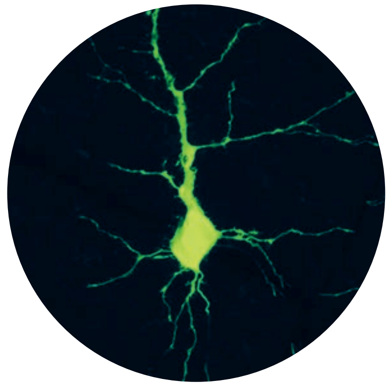
Pellicciotti Group
Wind of (Climate) Change

Rising global temperatures have caused Himalayan glaciers to increasingly cool the air in contact with the ice surface, according to ISTA researchers. The ensuing cold winds could help cool the glaciers and preserve the surrounding ecosystems.

Is global warming causing Himalayan glaciers to melt? Scientists have previously documented a warming effect that depends on altitude: mountain peaks "feel" the effects of global warming more strongly and heat up faster. But a high-altitude climate station at the base of Mount Everest showed that the measured surface air temperature remained suspiciously stable instead of rising.

The Pyramid Station has been recording hourly meteorological data for nearly three decades. Now, researchers co-led by ISTA Professor Francesca Pellicciotti have cracked the code. The warming climate is triggering a cooling reaction in the glaciers. It is causing cold winds—katabatic winds—to flow down the slopes now more than before. "This phenomenon is the result of 30 years of steadily rising global temperatures. The next step is to find out what the key characteristics of the glaciers that favor such a reaction are," says Pellicciotti. "Glaciers are still losing mass, and it will be necessary to see which effect is stronger: the local cooling that preserves some parts of the glaciers, or the overall warming." The consequences are far-reaching. The cooler air mass moves the point of precipitation down the valley, reducing a vital mass input of snow to the glaciers.

Neuroscience



A neuron of the cortex—the brain's outermost layer.

Novarino Group
Feed Them or Lose Them

The Novarino group examines how slight metabolic changes impact long-term brain development and function.

Our developing brains demand the right nutrients at the right time. This sustenance provides energy for cellular processes that underlie brain formation. But what happens if these substances are not available? A recent publication by the Novarino group, issued in *Cell*, sheds light on this brain mystery.

In collaboration with Viennese universities, the scientists profiled the nutritional program of the mouse brain. They found that large neutral amino acids (LNAAs)—an essential group of amino acids—play a key role during certain stages of brain development. "By checking the levels of metabolites throughout brain development, LNAAs seemed especially important for the neurodevelopmental period after birth," explains first author and recent ISTA graduate Lisa Knaus.

To decipher the role of LNAAs, the researchers starved neurons in developing mice of these amino acids. In the embryonic stages, brain formation appeared to be fine. However, after birth, nerve cells started to be affected by the low levels of LNAAs. Mice developed microcephaly—a reduction in brain size—as neurons became less active and vanished. Neuron death and activity rates normalized after this critical period. Nevertheless, the smaller brain size persisted until adulthood, eventually causing long-term behavioral changes.

Evolution & Ecology

Argentine ant with brood.

Cremer Group
How Sneaky Germs Hide from Ants

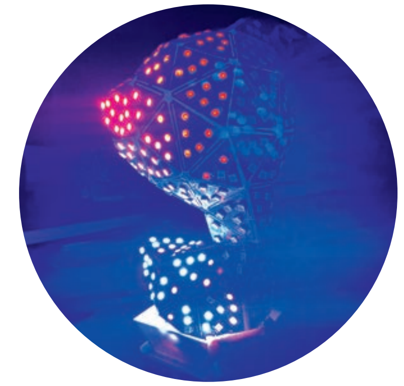
Pathogens reduce their detection cues to hide from social healthcare measures.

Ants exhibit collective hygiene measures, such as grooming off infectious particles from infected nestmates, to avoid the spreading of germs throughout the community. This makes it very hard for pathogens to succeed in social insect colonies. Whether and how pathogens respond to the social immunity of their hosts is still unknown. A study published in *Nature Ecology & Evolution* by the Cremer group and collaborators sheds light on this process.

The scientists infected Argentine ants with pathogenic *Metarhizium* fungi, either alone or in the presence of caregiving colony members. "Fungi that had to overcome grooming by caregivers boosted their spore production compared to fungi infecting ants in solitude," Sylvia Cremer explains. Moreover, the spores that adapted to social hosts elicited less grooming by the ants, suggesting they had become more difficult to detect.

To decipher this mystery, the researchers analyzed the spores' chemical bouquets. They found that adaptation to caring nestmates reduced fungal detection cues, in particular, a specific compound called "ergosterol"—an essential membrane compound that all fungi have. The germs are no longer recognized as a disease threat and can escape the healthcare measures of the colony. "It would be interesting to see how the ant colony will react in turn. Maybe the ants become more sensitive and detect lower levels of fungal cues," Cremer concludes.

Computer Science



From flat to cat. The 2D circuit boards created by the PCBend program are folded and programmed to create stunning 3D light sculptures.

Bickel Group
Origami-Inspired 3D Light Sculptures

The importance of light in design, art, and architecture is undisputed. However, designing and manufacturing light-covered 3D objects has been both prohibitively expensive and tedious for the average user.

This problem caught the attention of Manas Bhargava, a PhD student in the Bickel group at ISTA, who set about developing an easy-to-use and affordable pipeline to create and fabricate such structures. Now, Bhargava and colleagues at ISTA as well as the University of Lorraine, France, have introduced PCBend, a system that achieves exactly that.

Flat (2D) LED circuit boards are inexpensive and easily produced, unlike curved (3D) circuits. To keep costs low and make use of existing manufacturing chains, the team first found a method to flatten the target object design. "Unfolding a 3D object made of triangles is a classic problem, with solutions inspired by origami," explains Bhargava. "But we also had to account for the physical constraints imposed by the circuit connections between two triangles—unlike folded paper, they can break." Using woodworking techniques, the team created special hinges that would allow the printed circuit board to bend without severing the circuits. The team's program further solved the circuit layout problem, connecting all the LEDs along a single path. Once the 2D design mesh is set, it is manufactured and the user reassembles and programs the light patterns. Possible applications could be in art, theatre, and show elements of concerts.

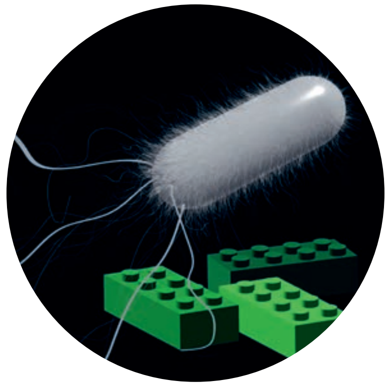
Control at the Nanoscale

The material scientists at ISTA are pushing boundaries and pioneering new territories. Aiswarya Puthiyaveettil and Christine Fiedler, PhD students in Maria Ibáñez' research group, are working at the nanoscale to create a new generation of materials with optimized properties for thermoelectric applications. Offering insights into the design and synthesis of new functional materials, their research holds promise for new directions in cost effective energy harvesting and transportation leading to a sustainable future. Together with their colleagues they use nanoparticles-based precursors that can be tuned by varying parameters like shape and size to strategically generate polycrystalline solids with features tailored to control the charge and phonon transport.

Material Science

Ibáñez group

Physics



Swimming bacteria forge materials from Lego-like building blocks.

Palacci, Hannezo, and Šarić Groups
Bacteria as Blacksmiths

A research team at ISTA uses a bath of swimming bacteria to assemble unconventional materials.

When suspended in water, tiny building blocks randomly move due to temperature-induced jiggling. The addition of "active agents" to the water creates an "active bath", thus adding forces and flows to the chaos. This extra energy allows control over material assembly and properties, similar to a blacksmith forging materials.

A cross-disciplinary research team of graduate students and postdocs from the Palacci, Hannezo, and Šarić groups takes this principle to the next level and leverages the energy of swimming bacteria to forge materials. Their findings have been published in *Nature Physics*.

For their experiments, the scientists used *E. coli* bacteria as an active agent and microscopic round beads as building blocks that stick together when in contact. The swimming bacteria effectively amplified the motion of the beads, resulting in the formation of aggregations and gel-like structures. Newly formed clusters exhibited a slow clockwise spin, attributed to the chirality of *E. coli* flagella—the minuscule appendages that propel the bacteria in their movement.

The approach was designed with scalability in mind, potentially enabling the creation of larger 3D samples down the line. "It would have never reached this conceptual and quantitative depth without the collaborative work fostered by ISTA," adds Jérémie Palacci.

Neuroscience

Two new imaging techniques offer unprecedented insights into the complex architecture of brain tissue. In this image: Tissue reconstruction using CATS.

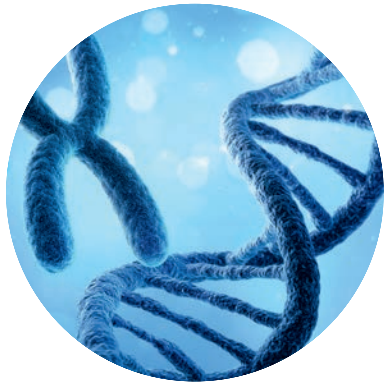
Danzl, Bickel, Jonas, Novarino, and Siegert Groups
CATS and LIONESS

In 2023, papers from ISTA's Danzl group describing technological advances in brain tissue imaging made it rain CATS and … LIONESS. Both techniques—with feline-inspired acronyms—were developed in collaboration with several ISTA research groups and the Scientific Service Units.

CATS (Comprehensive Analysis of Tissues across Scales) allows scientists to visualize the architecture of the brain in stunning detail. The technique labels the cell surfaces and spaces around cells while chemically preserving or "fixing" the tissue. This also gives insight into how the human brain architecture is altered by disease. "CATS visualizes brain tissue architecture in its entirety," explains Johann Danzl. "It locates cells and specific molecules in the micro- and nanoscale context, allowing us to decipher how the functional components of the tissue relate to each other."

In contrast, LIONESS (Live Information Optimized Nanoscopy Enabling Saturated Segmentation) provides an unprecedented "live" view into the brain's complexity. "With LIONESS, it is for the first time possible to obtain a comprehensive, dense reconstruction of living brain tissue," says first author Philipp Velicky. "By imaging the tissue multiple times, LIONESS allows us to observe and measure the dynamic cellular biology in the brain as it unfolds." Both techniques draw on a broad range of expertise available at ISTA, including imaging techniques, neuroscience, automated segmentation, visualization, and organoid technology.

Cell Biology
Physics



The motion of DNA controls gene activity.

David Brückner
DNA Organization in Real Time

An interdisciplinary group of scientists visualized and physically interpreted the motion of DNA inside the nucleus.

To fit into the cell nucleus, DNA undergoes compaction into chromosomes. Despite being heavily condensed, chromosomes exhibit dynamic movements. When specific genes need activation, two regions—the enhancer and the promoter—must come into close contact. "Previously, you could only get a static view of the distance between these elements, but not how the system evolves," explains NOMIS fellow David Brückner. Intrigued by this missing information, the scientists set out to get a dynamic look at how these elements are organized and how they move in 3D space in real time.

A team of scientists from Princeton University used live imaging in a fly embryo to track these elements. Visualizing them offered a distinct overview of how these elements maneuver to find each other. The challenge, however, was analyzing this huge data set of stochastic motion. His background in theoretical physics allowed Brückner to extract statistics to understand the typical behavior of the system. He applied two simplified, different physical models to cut through the data, resulting in a detailed description of the dense yet dynamically moving DNA structure. The study, published in *Science*, brings together the worlds of biology and physics and offers new insights into the characteristics of a chromosome, which might help to understand gene interaction and gene activation in more detail.

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 and training, or a state-of-the-art plant breeding facility.

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9 Scientific Service Units

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105 m² Plant Facility 2022

169 nanometers

The new Nano 3D printer allows to define structures down to 169 millionths of a millimeter.

+126.85 to −271.35°C

The temperature range that the new physical property measurement system in the Nanofabrication Facility can measure.

300,000

Thale cress and tobacco plants for science are hosted in the expanded Plant Facility.

211 m² Plant Facility 2023

Doubling in size since last year

Research Facilities

Services for Science

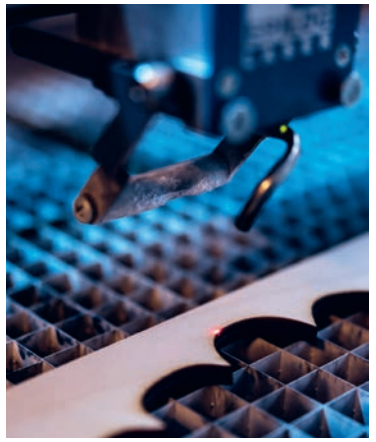
Mass spectrometers, LED-lit plant trays, nano-scale 3D printers, X-ray scattering, and precision laser cutters. The list of measurement devices and machines to create experiments at a major research institution like ISTA is extensive. Every day, dedicated teams of experts in the Scientific Service Units work with and on them to make research at ISTA possible.

Excellent science would be impossible without an excellent support system. In 2023, the Scientific Service Units (SSUs) at ISTA have once again demonstrated their capabilities and expanded their services with new experts, devices, and procedures.

Nanofabrication Facility

"This year, we expanded the Nanofabrication Facility with several new devices," Salvatore Bagiante, manager of the Nanofabrication Facility, explains. "The new Nano 3D printer now allows us to print 3D structures on the micro- meter scale and even to define structures down to 169 nanometers—that's 169 millionths of a millimeter." With this new machine, the SSU supports a multitude of projects that require tiny mechanisms, ranging from structures for cell growth to minuscule cogs for several research groups. Next to the Nano 3D printer, this SSU also installed a physical property measurement system. "Behind this somewhat generic name hides a wide range of measurement techniques with great versatility," Bagiante explains. "It can measure electric, thermal, and magnetic characteristics under a variety of external conditions, such as temperatures reaching from -271.35 to +126.85 degrees Celsius and magnetic fields from -14 to +14 Tesla—which is immense." Additionally, they also procured a new Raman spectroscopy system, which uses lasers to identify and characterize chemical composition in great detail. Bagiante mentions one of the highlights of 2023, "We created challenging 3D nanostructures with the 3D printer that otherwise would not have been possible."

The Nanofabrication Facility provides a cleanroom and offers tools that support scientists in their research endeavors.



Left: Precision laser cutters in the Miba Machine Shop are capable of cutting and engraving 2D plastic parts.

Right: In the "Pink Room" of the Plant Facility, Dorota Jaworska and her team take care of thousands of *Arabidopsis thaliana* plants.

Miba Machine Shop
The Miba Machine Shop was one of the first SSUs established at ISTA. Its team not only provides mechanical and electronic solutions to support science but also improves and customizes any device and experimental equipment. "With our ten employees and a wide array of machines—ranging from mills to laser cutters and 3D printers—we enable ISTA's researchers to achieve results ahead of others using standard equipment," Todor Asenov, Machine Shop manager, explains. "One of the most exciting projects of 2023 was a sealed-off wireless ohmmeter for the Katsaros group." This apparatus allows the researchers to remotely measure the electrical resistances of metal in a vacuum chamber to control the production of certain parts for quantum mechanical experiments. "It took us a year, but with our combined creativity and a great collaboration between the Machine Shop and the scientists, we created a one-of-a-kind device."

Lab Support Facility
The Lab Support Facility includes a wide variety of specialized support facilities for both life sciences and physical sciences, each with dedicated teams of specialists. Several groups at ISTA use the Plant Facility to breed plants for research. "We had to expand our facility to accommodate all the plants," Dorota Jaworska, Plant Facility technician, recounts 2023. "We doubled the available space and also welcomed a new team member." With the expansion, the facility can now grow around 30,000 thale cress and tobacco plants for science, as well as a species of liverworts—a kind of moss—that was newly introduced in 2023. "We also equipped the growth chambers with LED lights, with which we can adjust color and light levels," Jaworska adds. "Together with the researchers, we have been planning new projects to try outgrowing the plants using just individual wavelengths of light." In the physical sciences branch of the Lab Support Facility, the new Material Characterization Service was started in 2023 with devices that analyze the nanometer-scale structure of samples using X-rays. The Mass Spectrometry Service is focused on the analysis of proteins, their modifications, and their interactions. In 2023, its team also made a major investment in a novel, highly sensitive mass spectrometer.

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

A New Innovation Ecosystem

Scientists at ISTA explore the quantum realm of the tiniest of particles, map the intricate pathways of the brain, and create detailed digital models of the world. This kind of frontier research can also be the source of applications that impact society and the world. The xista innovation ecosystem that was launched in 2023, provides a fertile environment for ISTA and beyond, where new ideas and companies can flourish.

xista strives to be a role model in enabling innovation. It builds connections between science and industry, supports researchers from the inception and development of an idea to the founding and financing of a company, and hosts them close to ISTA's laboratory facilities. Markus Wanko, managing director of xista, looks back at the year 2023, "We not only launched xista, but also expanded its services and investments. We founded and invested in new companies—for the first time also abroad—, secured new tenants for our xista science park, carried out new entrepreneurship training programs, and redesigned our flagship event bigX."

xista innovation
xista innovation is a company dedicated to commercializing research, building links to industry, and training the next generation of scientific entrepreneurs. It has already spawned several start-ups to commercialize ISTA research in areas ranging from AI architecture to neurological therapeutics. In 2023, xista innovation launched XBIO, a joint training program for aspiring biotech entrepreneurs. In cooperation with the University of Vienna, the Medical University of Vienna, the CeMM Research Center for Molecular Medicine, the high-tech business incubator INiTS, the KHAN Technology Transfer Fund I, and the Austria Wirtschaftsservice, it brings together researchers with experienced founders and CEOs. The program guides the participants from the concept phase to a first business plan for a pitch-ready biotech company. "XBIO has been very successful," Ingrid Kelly, life science lead at xista innovation, adds. "We have received many applications, the output of the first cohort of participants has been excellent and has already led to the foundation of a new company. We very much look forward to the next iteration in 2024."

ISTA's brand-new Moonstone Seminar Center was a great venue for bigX, xista's annual science innovation event.

In October, bigX, the relaunched annual science innovation event, took place at ISTA's brand-new Moonstone Seminar Center. More than 240 attendees enjoyed the program, the start-up eXchange, networking opportunities, and an inspiring keynote by IC-MedTech CEO Tom Miller. Together with the Federation of Austrian Industries, xista invited participants to explore ISTA's latest spin-off ventures and learn about new scientific fields for potential market applications.

xista science ventures

Once a technology idea has been developed, successful commercialization requires funding to launch a new company. xista science ventures is a venture capital fund that provides investments, expertise, and networks to help science-based companies grow. Its first fund—formerly known as IST cube—raised 45 million Euro in 2021 and has so far supported 19 high-tech companies both in Austria and abroad. Collectively, these companies have raised over 130 million Euro in capital and employ more than 200 people. "In 2023, we invested in several new start-ups spanning a wide variety of scientific fields," explains Alex Schwartz, managing partner at xista science ventures. "Syntropic Medical and Tulon Photonics were the highlights of the year." Neuroscientist and ISTA professor Sandra Siegert founded Syntropic Medical based on research from her lab. Its aim is to test an innovative drug-free treatment approach in humans and ultimately to bring a medical device to market to treat mental health conditions such as post-traumatic stress disorder or depression. Tulon Photonics on the other hand is a promising spin-off project from the Hosten group at ISTA that develops ultra-low noise lasers for the optical devices industry. In 2023, xista fellow Fritz Diorico made great progress working on this technology and its incorporation is planned for 2024. Schwartz concludes, "We saw both our portfolio grow into new directions and our previous investments flourish. Expanding abroad will grant us and our founders a greater network and strengthen xista and ISTA as a European hub for innovation."

xista science park

A science-based company requires space to do research and close contact with researchers and their institutions. xista science park is a joint venture of ISTA and ecoplus and provides infrastructure as well as lab space for start-ups. These companies have specific needs like access to state-of-the-art scientific infrastructure and skilled operating teams. xista science park operates two dedicated buildings adjacent to the ISTA campus with fully equipped molecular biology labs, and it also facilitates access to the Institute's infrastructure. "Now, we are fully booked," says Wanko. "This year, another company, Vertus Energy, moved in. Their work on carbon sequestration and anaerobic organic decomposition will benefit from the connections made at the science park." With a full house, the xista team is already planning the future expansion of the xista science park.

"We saw both our portfolio grow into new directions and our previous investments flourish."

Alex Schwartz, managing partner at xista science ventures

xista science ventures backs spin-offs well beyond ISTA, both in Austria and abroad

- ↗ **ReCatalyst** is developing new catalysts for fuel cells, which turn hydrogen and oxygen into electricity and water. The Slovenia-based company aims to optimize these catalysts for future electric vehicles.
- ↗ **Infrared City** builds AI models that aim to reduce the time, cost, and complexity of simulating the different climate conditions of cities in great detail.
- ↗ **Subdron** builds autonomous underwater drones for inspecting ships and underwater structures to create high-resolution scans of damages like biofouling.
- ↗ **Rivus Batteries** builds batteries with low environmental impact, using organic materials instead of rare earth elements like lithium and cobalt.

The team behind the newly launched xista ecosystem, which enables innovative technology transfer.

Supporters

Building Connections Beyond Science

Innovation and change at ISTA do not only happen in science. With a new president and a continued fundraising campaign, the Development & Partnerships team increased its efforts in 2023 to strengthen the Institute's connections to industry as well as existing and potential donors. Several prestigious awards for the Institute and its members confirmed its success in 2023.

2023 was a special year in ISTA's history. After 14 years as the first president of the Institute, Thomas A. Henzinger handed over his position to Martin Hetzer in January of that year. The Development & Partnerships team introduced the new president to ISTA's wide network of stakeholders, highlighted ISTA's research and innovation ecosystem, and expanded the Institute's network. While starting his position at the beginning of the year, Hetzer was officially inaugurated with an event in April 2023. More than 250 representatives from science, politics, and industry joined the ceremony, where Henzinger handed over the newly designed chain of office to Hetzer as a symbol representing the Institute's goals, values, and fields of research.

Recognition and connection

Next to introducing the new president, several major events and prestigious awards highlighted ISTA's status as a center of excellent research and innovations. "In October 2023, ISTA received the special award for Innovation & Entrepreneurship Enabler Of The Year 2023 at the Ernst & Young Entrepreneur of the Year gala. We also received the Fundraising Award for being the fundraiser of the year by the Fundraising Verband Austria," Maria Maager, new head of the Development & Partnerships team, explains. In November, ISTA, together with Ernst & Young and the Lower Austria-Vienna branch of Raiffeisen Bank, gathered 120 leaders of Austrian businesses as well as Martin Polaschek, Federal Minister for Education, Science and Research, at the Leaders Forum 2023 in Vienna. There, Hetzer and ISTA Professor Monika Henzinger represented the Institute at a panel discussing how scientists and their discoveries underpin our economy. "Ultimately, the origin of all innovation can be traced back to fundamental research. This is exactly what we at ISTA are all about," Hetzer stated at the event.

VERBUND Professor for Energy Science Maria Ibáñez tours the board of VERBUND AG through the lab and gives insights into functional nanomaterials.

Securing research autonomy

Alongside public funding, peer-reviewed research grants, and technology licensing, the Institute's long-term financial health relies on donations. With its first of a kind capital campaign "Be a Giant", ISTA aims to raise 100 million Euro for an institutional endowment to support independent research and graduate education in perpetuity. It was initiated by an extremely generous donation by Lower Austrian entrepreneur Magdalena Walz, who left the Institute 25 million Euro in her will. Since 2022, the capital campaign has raised another five million Euro—a donation by Verbund AG, Austria's largest electricity provider. Both donations lead to the establishment of named professorships in recognition of the generous gifts: the Magdalena Walz Professor for Life Sciences currently held by neuroscientist Peter Jonas and the Verbund Professor for Energy Science held by material scientist Maria Ibáñez. Apart from named professorships and grants for doctoral or postdoctoral positions at ISTA, the Institute's independent research can be supported via project-based donations that are aimed at supporting specific projects at ISTA. Lastly, several of the buildings on the ISTA campus are open to being named based on donations.

> "Ultimately, the origin of all innovation can be traced back to fundamental research. This is exactly what we at ISTA are all about."
>
> Martin Hetzer, President

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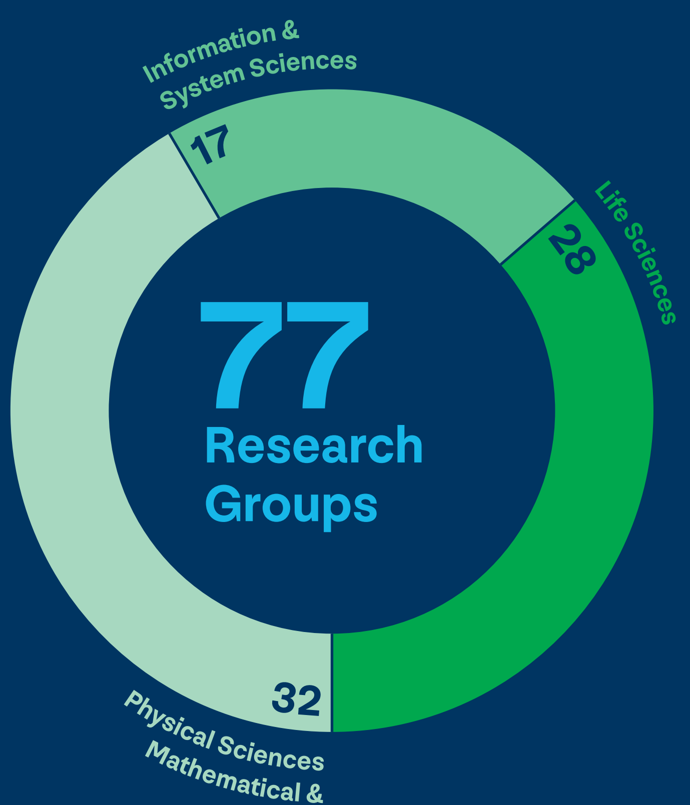
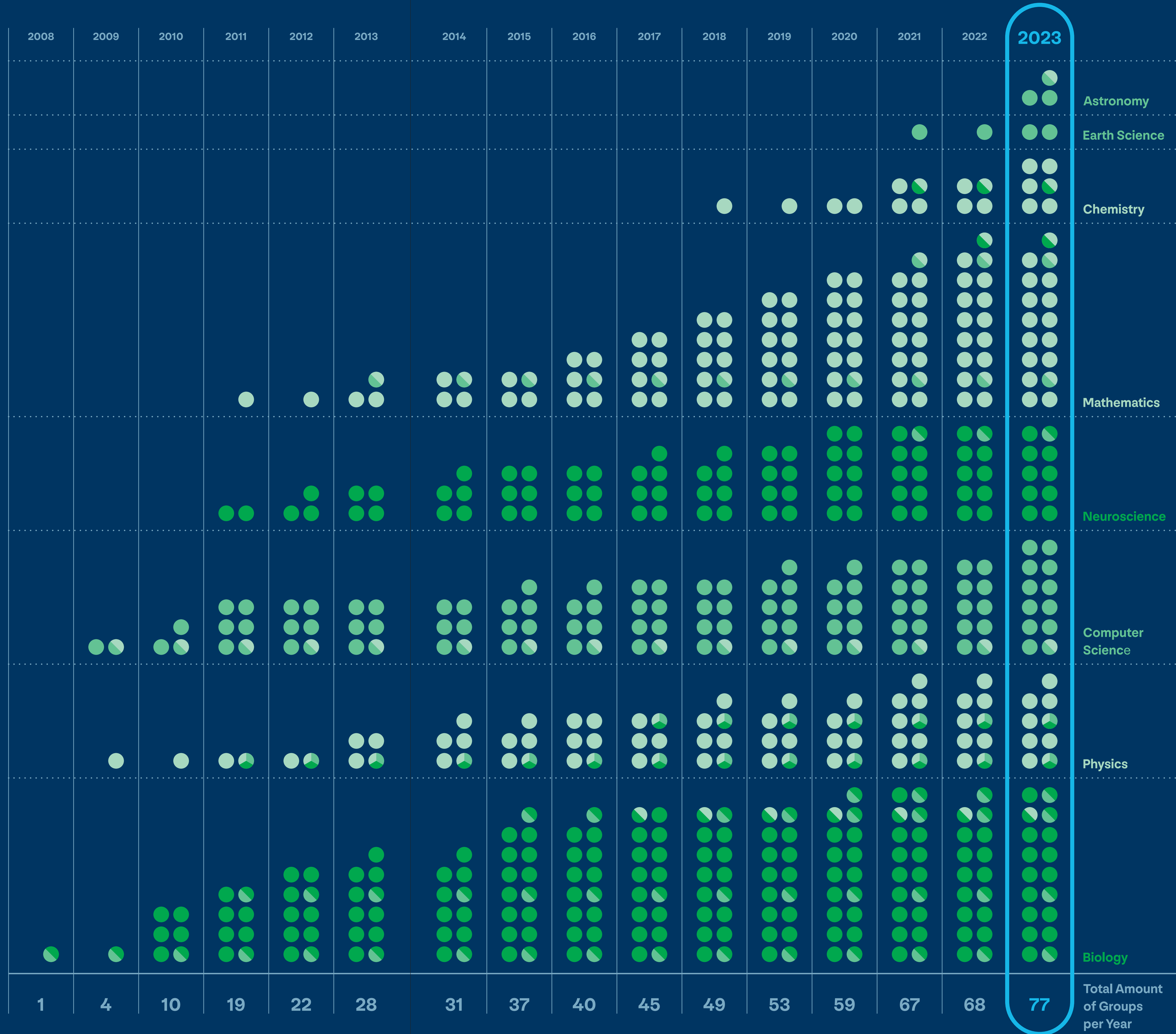
Pioneering Excellence

From a few research groups in limited fields, research at ISTA now encompasses a broad spectrum of disciplines, deliberately transcending their boundaries. Each new scientist contributes to the diversity of research and the richness of ideas on campus.





Multicolored Circles Stand for Groups with a Cross-Disciplinary Character

New Professors

Contracts signed as of December 31, 2023

ISTA welcomes six new professors who have signed contracts and will join the Institute from January 2024 to January 2025. These exceptional researchers will play a pivotal role in advancing ISTA's vision of fostering 150 research groups by 2036 who follow their curiosity to new scientific heights.

The opening of the Moonstone Building, the sixth laboratory building on campus, marked the end of the second of three expansion stages en route to doubling the Institute's size by 2036. The addition of new buildings corresponds to an increasing number of employees, including outstanding new faculty members. In 2024, six professors with diverse backgrounds and research fields spanning astronomy, computer sciences, physics, chemistry, biochemistry, and cell biology, enrich the Institute. Supported by various scientific services ISTA is offering to all its researchers, they will follow their curiosity to wherever it takes them.

To create and disseminate knowledge and steer science in new directions, ISTA considers equality, diversity, and inclusion to be essential. ISTA recognizes that despite the even distribution of talent, many groups are still poorly represented in leading-edge research. The Institute strives for a diverse community, actively encourages applications from women faculty, and sets measures to minimize bias in hiring decisions.

Denitsa Baykusheva
Ultrafast Quantum Phases and Spectroscopy

Chemistry
Physics

In certain materials, quantum mechanical properties manifest themselves over a wide range of energy and length scales, giving rise to macroscopic phenomena such as superconductivity or spin liquidity. These phases can be manipulated by external stimuli. Ultrashort laser pulses have emerged as a new method to control these quantum phases, making the stabilization of transient states that lack an equilibrium counterpart possible. However, ultrafast light-matter interactions have mostly been seen from a "semiclassical perspective", combining quantum matter treatment with a classical view of the electromagnetic field.

Denitsa Baykusheva aims to bridge the gap and bring ultrafast spectroscopy to the fully quantum regime. Her goal is to create spectroscopic tools that can also characterize and manipulate the quantum aspects of light fields. The ability to map photon correlations onto matter and vice versa holds the promise of uncovering new aspects of light-matter interactions, potentially leading to the discovery of new functionalities.

Baykusheva was a postdoctoral scholar at the Department of Physics at Harvard University, USA, from 2020 to 2023, and at the Stanford PULSE Institute, SLAC National Laboratory, USA, from 2018 to 2020. Before that, the physicist earned her PhD in 2018 at ETH Zürich, Switzerland.

Denitsa Baykusheva will join ISTA in January 2024.

Jack Bravo
Bacterial Immune Systems

Biochemistry
Cell Biology

Bacteria and their parasites are in an ongoing arms race. This evolutionary pressure has driven the development of sophisticated bacterial defense systems capable of providing immunity. Recent advancements in the field have unveiled a plethora of enigmatic defense mechanisms. Although their exact characteristics are not entirely grasped, it is evident that they need to differentiate between self and non-self molecules to prevent unintended activation and autoimmunity.

Jack Bravo's particular interest lies in understanding how these diverse bacterial immune systems can identify an intruder's nucleic acids from their own. His group will use a combination of structural biology (e.g. cryo-electron microscopy), biochemistry, biophysics and functional assays to decipher the molecular mechanisms that underpin immunity. Their ultimate goal will be to harness the knowledge to turn these immune response machineries into potent tools for genome editing and diagnostics.

Bravo earned his doctorate at the University of Leeds, UK, in 2019. He then proceeded with his postdoctoral career in Cambridge, UK (2019) and at the University of Texas at Austin, USA (2020–2024).

Jack Bravo will join ISTA in July 2024.

Ilaria Caiazzo
Stars and Compact Objects

Astronomy

Stellar astrophysics is experiencing an exciting era. The advent of high-cadence time domain surveys like Gaia, ZTF, and the Vera Rubin Observatory revolutionized the landscape of stellar studies by allowing the exploration of the dynamic sky. Additionally, space missions such as the James Webb Space Telescope, renowned for its unprecedented sensitivity in the infrared, are opening new windows on the skies above us.

Ilaria Caiazzo takes advantage of these rich datasets to study stars and their remnants at their last stage of life (e.g. white dwarfs, neutron stars, and black holes) and to explore their evolution. She is interested in understanding their laws of physics, as they encompass extremes that cannot ever be achieved on Earth—from gravitation to density and magnetic fields. At ISTA, her research group will combine observation, analysis of large datasets, and theoretical work to tackle open questions about stars and their remnants.

Before becoming an assistant professor at ISTA, Caiazzo was a Sherman Fairchild Postdoctoral Fellow in theoretical astrophysics at the Burke Institute, Caltech, Pasadena, USA, from 2019 to 2024 and earned a PhD in 2019 at the University of British Columbia, Canada.

Ilaria Caiazzo will join ISTA in May 2024.

Alicia Michael
Genome Regulation and Biological Timekeeping

Biochemistry
Cell Biology
Chemistry

Circadian rhythms sync physiology and behavior to the daily light-dark cycle. Disruption in these rhythms in mammals, caused by external factors or genetics, is linked to diseases like diabetes, cardiovascular issues, aging, and cancer. In humans, almost every cell bears an internal 24-hour molecular clock, directing vital processes including DNA organization, gene activity, and cellular functions.

Alicia Michael's lab tries to utilize the circadian systems to unravel the fundamental principles of gene regulation and gain insights into how cells keep time. They look at how genes and large molecular structures are arranged within the nucleus of cells and are eager to understand how this architecture affects the environmentally sensitive on/off switching of genes. The research group employs various techniques ranging from biochemistry, chemical biology, and genomics to cryo-electron microscopy (cryo-EM).

In 2017, Michael earned a PhD from the University of California, Santa Cruz, USA. The cell and structural biologist subsequently held a postdoctoral position at the Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland, from 2017 to 2022, with an EMBO and HFSP long-term fellowship, and at the Biozentrum of the University of Basel, Switzerland, from 2023 to 2024.

Alicia Michael will join ISTA in April 2024.

Florian Praetorius
Biomolecular Design

Biochemistry
Cell Biology

Individual proteins fold into specific shapes that determine their functions. Complex structures consisting of multiple proteins derive their function from their overall shape or how their parts are positioned. To create new shapes and structures with novel or optimized functions, Florian Praetorius uses biomolecular design, which specializes in two types of building blocks: proteins and nucleic acids (DNA and RNA).

At ISTA, he will use deep learning-based computational and conventional physics-based protein design tools to generate new proteins from scratch. He will also harness DNA origami for crafting shapes and structures at the nanoscale level. The biochemist aims to create unique DNA-protein hybrid assemblies, which eventually will possess novel functions and properties beyond what each technique can achieve independently. This research promises to advance areas such as gene delivery, gene editing, or vaccine development.

After earning his PhD in 2018 at the physics department at the Technische Universität München, Germany, Florian Praetorius continued his career as a postdoctoral researcher at the University of Washington, USA, from 2018 to 2024.

Florian Praetorius will join ISTA in March 2024.

Michael Sammler
Programming Languages and Verification

Computer Science

Modern computers depend on low-level systems software like operating systems or hypervisors. Such software often provides critical components that ensure the reliability and security of the overall system. However, this means that bugs and vulnerabilities in those systems can lead to failures and security problems. Thus, detecting and preventing such bugs is crucial to ensuring the reliability of modern computers.

Michael Sammler achieves this by using formal verification, which allows proving that a program behaves as described by a high-level mathematical specification. At ISTA, the computer scientist's research group will develop methodologies that can verify real-world code against realistic models of programming languages like C or assembly languages, while providing a high degree of automation and producing machine-checkable proofs in a proof assistant.

Michael Sammler earned a PhD in 2023 from the Max Planck Institute for Software Systems in Germany. He is currently a postdoctoral researcher at ETH Zurich, Switzerland.

Michael Sammler will join ISTA in 2025.

The Moonstone Building, which opened in 2023, is home to some of the newest research groups on campus and also offers future faculty members and their teams state-of-the-art laboratories and office space.

Research Groups

ISTA faculty members venture into uncharted territories through their research, often navigating the intriguing intersections of various scientific disciplines. Annually, around six new professors and assistant professors are appointed exclusively on the basis of research promise and excellence. Each of them heads their own research group—by the end of 2023, the campus is home to 76 groups portrayed hereafter.

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, and information and system sciences. Research groups at ISTA may attribute themselves to more fine-grained disciplines. However, many are also pioneers in new research fields or actively contribute to blurring the lines between traditional disciplines.

Faculty calls have always been independent of fields; yet, recruiting acknowledges the positive effect of "clusters" within fields. They enable discourse and exchange, which is beneficial to developing innovative ideas. By 2036, the Institute will host around 150 research groups, further expanding its research spectrum with outstanding applicants 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 developing new ways to overcome these limitations.

Current projects: Efficient Training and Inference for Massive Models; 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: the recovery dynamics will reveal a great deal about its inner workings. The Alpichshev group uses ultrafast 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, Stanford, USA

Barton Group
Evolutionary Genetics

Data Science
Evolution & Ecology
Mathematics

The Barton group develops mathematical models to probe 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 and 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 the 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 spaces of rational curves; Rational points on Fano varieties; Arithmetic statistics; Hardy-Littlewood circle method; Sieve theory and divisibility sequences

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

Bugnet Group
Asterics – Asteroseismology and Stellar Dynamics

Astronomy
Data Science

Understanding internal processes taking place inside stars is key for their accurate characterization, giving us constraints for the understanding of 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 about our understanding of stellar evolution, which in turn would have far-reaching consequences for our understanding of the universe.

The Bugnet group aims at understanding the magnetic evolution of stars and their dynamic processes thanks to Asteroseismology. Stellar magnetic fields, from the core to the envelope of the star, are at the center of the Asterics group's research. Magnetic fields are largely excluded from stellar evolution models due to a lack of observation and theoretical prescriptions. Research in the group combines theory, models, and observational constraints from asteroseismology to improve our understanding of stellar magnetic fields, as they are essential for the understanding of the evolution of stars like the Sun.

Current Projects: Detection and characterization of magnetic fields inside stars; Magnetic fields at convective/radiative interfaces; Angular momentum transport by magnetism in stellar interiors; Stellar magnetism across the Hertzsprung-Russell diagram; Machine learning for Asteroseismology and the PLATO space mission

Lisa Bugnet

Career: Since 2023 Assistant Professor, ISTA
2020–2022 Flatiron Research Fellow, Flatiron Institute, Simons Foundation, New York, USA
2020 PhD, The French Alternative Energies and Atomic Energy Commission (CEA), Université Paris-Cité, Paris, France

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 the 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 the theoretical foundations of game theory, its 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 materials 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 cooperative actions.
Ants and other social insects are able to detect and react to the presence of infectious pathogens, even before they cause disease. This is because ants sense the pathogens' chemical cues, which trigger highly effective caregiving behaviors toward pathogen-exposed colony members. In collaboration with theorists (K. Boďova and G. Tkačik) the Cremer group could further reveal that ants can dynamically react to the changing pathogen threat in their colonies by integrating both the perceived pathogen load on others and the social feedback they receive on their own infectivity by their colony members. Simple individual decision rules thus combine to highly efficient collective hygiene.

Current projects: Pathogen spread and disease prevention in social insects; Epidemiology along social interaction networks; Collective disease resistance and tolerance; Pathogen detection and infection treatment

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 to encode these memory traces. The Csicsvari group studies how learning is implemented in the brain.
During learning, new memories are acquired and then consolidated to ensure their successful later recall. 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
2003–2011 MRC Senior Scientist (tenure-track and tenured), MRC Anatomical Neuropharmacology Unit, University of Oxford, UK
1999–2002 Postdoctoral Fellow and Research Associate, 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

Neuroscience
Data Science
Cell Biology
Physics

How can we decode the molecular architecture of biological systems? How can we analyze 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 applying a set of advanced light microscopy tools.
The Danzl group explores and extends the possibilities of optical imaging, reaching from the organ level to the subcellular nanometer range, at much better resolutions than the limits of classical light microscopy. With their technological developments, the group aims to access novel qualities of information from biological specimens. The group works toward reconstructing brain and other cells/tissues with structural and molecular detail at nanoscale resolution, employing an integrated multi-disciplinary approach spanning from optical physics and advanced data analysis to the biological application.

Current projects: Synapse-level reconstruction of brain tissue; Optical imaging of cell and tissue ultrastructure; Molecular characterization in spatial tissue context

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*. This animal's relative simplicity provides special opportunities to understand behavior in cellular and molecular terms. The worm's rich behavioral repertoire provides readouts of neuron and circuit functions. Each of its neurons can be identified and visualized *in vivo*, and selectively manipulated using transgenes. Neural activity can be monitored in behaving animals using genetically encoded sensors. Powerful genetics and advanced genomic resources make high-throughput forward genetics and single-neuron profiling possible. Genetics is complemented by biochemistry and *in vivo* microscopy, to get at 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: How to switch between global animal states; *In vivo* biochemistry at single-cell resolution; Neuroimmune signaling; Gap junctions structure and function; Evolution of behavior

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, 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 (C4/W3), 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

Feng Group
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 pass down the genetic information 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.

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

Through addressing these questions, the Feng group hopes to provide deep insights into epigenetic mechanisms and germline functions and reveal core principles governing epigenetic regulation of sexual reproduction in eukaryotes.

Current projects: DNA methylation reprogramming in land plants; Chromatin configuration in plant germlines; Epigenetic inheritance and resetting across generations; Mechanisms underlying thermal sensitivity of male reproduction

Xiaoqi Feng

Career: Since 2023 Assistant Professor (fast track to professor), ISTA
2014–2022 Group Leader (2014–2019, tenure-track; 2019–2022, tenured), John Innes Centre, Norwich, UK
2011–2014 Postdoctoral Fellow, University of California, Berkeley, USA
2010 PhD, University of Oxford, UK

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 quantum technology for simulation, communication, metrology, and sensing.

One of the Fink group's goals is to develop a router that converts a microwave photon to an optical photon with near-unity efficiency. With such devices, the researchers seek to perform quantum communication between superconducting circuits via robust fiber optic links at room temperature. Another focus area of the team is to develop new qubit-encoding concepts that offer intrinsic protection from noisy environments.

The group has observed fluxon lifetimes of more than three hours in a recently demonstrated superconducting qubit and is exploring new concepts of dynamical control to implement nanosecond timescale quantum gates in such circuits.

Current projects: Circuit and waveguide quantum electrodynamics; Quantum electro- and optomechanics; Quantum electro-optics and microwave photonics; Ultra-high impedance physics; 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, also connecting to areas like numerical analysis or probability.

Partial differential equations (PDEs) 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. 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 ideally 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 physicochemical 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, Université de 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: Auxin signaling; Second messengers in plant signaling; Auxin transport; Cell polarity and polar targeting; Endocytosis and recycling

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 level of 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

Götberg Group
Massive Binary Stars

Astronomy
Physics

Stars more massive than 8 times the mass of the Sun are rare, but important for the evolution of our Universe. Massive stars emit highly energetic ionizing radiation, have strong stellar winds, and explode in violent supernovae, thus acting as both the mechanical engines and the chemical factories that drive galaxy evolution.

Only in the last decade, it has become clear that the standard, single stellar evolution representation for massive stars is incorrect. Instead, massive stars orbit a companion star so closely that interaction is inevitable as the stars evolve and swell.

The binary interaction is typically dramatic: the stars transfer mass, engulf their companion, or even merge. One of the most common outcomes is stars stripped of their hydrogen-rich envelopes.

The Götberg group pursues observational, computational, and theoretical work, related to the first set of observed intermediate-mass stripped stars that they recently discovered.

Current projects: Observational searches for helium stars stripped in binaries; Evolutionary pathways leading to envelope-stripping in massive binary stars; Characterization of post-interaction binary stars; Physical processes operating in the interiors of massive stars; Ionizing radiation and feedback from massive interacting binaries; The origin of helium-ionizing radiation

Ylva Götberg

Career: Since 2023 Assistant Professor, ISTA
2020–2023 NASA Hubble Postdoctoral Fellow, Carnegie Institution for Science, Pasadena, USA
2019–2020 Alvin E. Nashman Postdoctoral Fellow, Carnegie Institution for Science, Pasadena, USA
2019 PhD, University of Amsterdam, Amsterdam, The Netherlands

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.

The Hannezo group is 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 spatiotemporal 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 theory 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—again, 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 in the spaces. Using methods from representation theory and combinatorics, the team can give results and conjectures that have previously been described by physicists and number theorists in other terms, thus connecting a wide 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 common and 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

Monika Henzinger Group
Algorithms

Computer Science

The research field of efficient algorithms and data structures seeks to understand how to save computing resources, both by designing better algorithms and by proving bounds on the limits of possible savings.

The M. Henzinger group is interested in developing efficient algorithms in settings where the input changes incrementally.

This applies to problems such as maintaining clusters–sets of points that are close to each other–in changing point sets as well as maintaining properties in graphs that are incrementally modified.

An additional consideration when dealing with real-world applications is data privacy. Differential privacy is a way to share information about data (such as clusters) while disturbing the information enough to protect the privacy of the individuals. The M. Henzinger group studies differential privacy in the context of dynamic inputs.

Current projects: Efficient algorithms and data structures, especially in dynamic settings; Responsible computing, especially differential privacy; Algorithms engineering

Monika Henzinger

Career: Since 2023 Professor, ISTA
2009–2023 Professor, University of Vienna, Austria
2005–2009 Professor, EPFL, Lausanne, Switzerland
1999–2005 Director of Research, Google
1996–1999 Research staff, Digital Equipment Corporation, USA
1993–1996 Assistant Professor, Cornell University, USA
1993 PhD Princeton University, USA

Thomas Henzinger Group
Design and Verification of Concurrent and Embedded Systems

Computer Science

Humans and computers are similar: While the interaction between two actors may be simple, every additional actor complicates matters. The T. Henzinger group builds the mathematical foundations for designing complex software systems.
Software is among the most complicated artifacts we create, making software bugs unavoidable. The T. 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 sometimes bugs show up after years of flawless operation. Embedded systems interact with the physical world; an additional challenge for them is to react to inputs at the right times. The group develops mathematical methods and computational tools for improving the reliability of concurrent and embedded software.

Current projects: Modeling, analysis, and synthesis of autonomous agents and cyber-physical systems; Quantitative model checking; Monitoring the safety, security, and fairness of software; Trustworthy AI; Formal methods for quantum computing

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
1996–2004 Assistant, Associate, and Full Professor, University of California, Berkeley, USA
1992–1995 Assistant Professor, Cornell University, Ithaca, USA
1991 Postdoc, Université Joseph Fourier, Grenoble, France
1991 PhD, Stanford University, Palo Alto, USA

Hetzer Group
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. The Hetzer Group researches the impact of cumulative changes during adulthood on health and disease development, focusing on cell maintenance and repair mechanisms.
The group is particularly interested in understanding how non-dividing cells such as neurons function throughout a lifetime and how cells lose control over the quality and integrity of proteins and important cell structures during aging. The ultimate goal is to utilize these mechanisms to delay the age-related decline of organs with limited cell renewal, such as the brain, pancreas, and heart.
The Hetzer group applies genomics, proteomics, and advanced imaging techniques to investigate how adult tissues are maintained and repaired, and why long-lived cells fail to work properly as a cell ages. The group's work on long-lived proteins (LLPs) in the nucleus, which exhibit no or very little protein turnover in the adult brain, could have major implications in preventing and treating disorders like Alzheimer's disease.

Current projects: Investigating a possible link between protein longevity and the maximal lifespan of an organism

Martin Hetzer

Career: 2023 Professor/President, ISTA
2016–2022 Senior Vice President, Salk Institute in San Diego, California, USA
2011–2022 Professor, Salk Institute in San Diego, California, USA
2004–2011 Assistant Professor, Salk Institute in San Diego, California, USA
1997–2003 Postdoc, European Molecular Biology Laboratory (EMBL), Heidelberg, Germany
1997 PhD, University of Vienna, Austria

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 glial 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 of advancing the general understanding of brain function and why human brain development is so sensitive to the 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 towards 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, e.g., for force or acceleration sensing, or making ultra-precise clocks, 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 optomechanical 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 a 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 of 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? The group combines nanophysiology, presynaptic patch-clamp and multi-cell recording, two-photon Ca^{2+} 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 Senior 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 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 (*Drosophila melanogaster*) 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 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. Vadim 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. Astronomers 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 large number of microelectronic applications that surround us—a development made possible by the invention of the transistor in the 50s. This—at the time—a few centimeters large device and product of scientific curiosity led to a technological revolution. 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

Klajn Group
Nanoscience and Supramolecular Chemistry

Chemistry

Life is possible thanks to a diverse repertoire of weak, noncovalent interactions, which allow cells, tissues, and organisms to grow and adapt to external cues. In sharp contrast, most human-made materials are held together by strong interactions, and they lack the ability to reconfigure themselves. The Klajn group seeks to understand the principles of self-assembly at the molecular scale and nanoscale and adopt them to develop novel synthetic assemblies and, ultimately, responsive materials.
Self-assembly is a powerful synthetic tool for constructing hierarchical materials with multiple layers of organization. For example, we rely on weak metal-ligand and van der Waals interactions to organize single layers of organic molecules on the surfaces of nanometer-sized crystals. These surface-decorated nanocrystals are programmed to self-assemble into higher-order crystals (supracrystals) by means of Coulombic interactions, which can subsequently come together to afford materials of macroscopic dimensions. We are particularly interested in building blocks responsive to external stimuli, such as light and magnetic fields. In the long run, this research might lead to new energy-efficient and environmentally friendly materials.

Current projects: Self-assembly of novel metal-organic architectures; Photoresponsive supramolecular assemblies; Self-assembly of supercharged nanoparticles into colloidal crystals

Rafal Klajn

Career: Since 2023 Professor, ISTA
2020–2023 Professor, Weizmann Institute of Science, Israel
2016–2020 Associate Professor, Weizmann Institute of Science, Israel
2009–2015 Assistant Professor, Weizmann Institute of Science, Israel
2009 PhD, Northwestern University, USA

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

Computer Science

Computing enabled society to interconnect transcending physical limits. Trust is often sacrificed in the name of efficiency and speed. The challenge: 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, where various research questions have emerged: 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

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, surprisingly often it is 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. Mikhail Lemeshko 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 so doing, 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, previously unobserved 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

Locatello Group
Causal Learning and Artificial Intelligence

Computer Science
Data Science

Modern machine learning is still limited to a superficial description of reality that only holds when the experimental conditions are fixed. It largely ignores interventions in the world, domain shifts, and temporal structure. The Locatello group focuses on learning causal representations and causal models from data to address these issues. Through rigorous theory and scalable algorithms, they enable AI agents to understand cause-and-effect relationships, the effect of interventions, and distribution changes underlying the data they encounter.

Advances in causal learning have promising applications in machine learning and artificial intelligence, including robustness, explainability, and fairness in recognition, reasoning, and planning tasks. Most importantly, their impact extends to discovering new scientific knowledge from massive amounts of data and serving as the interface between people and complex systems for decision-making. The Locatello group aims to solve open problems in machine learning and enable new applications in the sciences.

Current projects: Causal discovery; Causal representation learning; Object discovery; Visual reasoning; Deep learning methods; AI for science

Francesco Locatello

Career: Since 2023 Assistant Professor, ISTA
2020–2023 Senior Applied Scientist, Amazon Web Services
2020 PhD, ETH Zurich (Max Planck–ETH Center for Learning Systems), Switzerland

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 in 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 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. Mathematician Jan Maas 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: Optimal transport on random networks; Rates of convergence for evolutionary dynamics; Entropy inequalities and 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

Matthee Group
Astrophysics of Galaxies

Astronomy

Galaxies are the largest bound structures in our Universe and consist of gas, stars, planets, black holes, and dark matter. The astrophysical processes that occur in galaxies have happened to every atom in our body and therefore teach us about our cosmic origins.
Galaxies form following the collapse of small perturbations in the initial density distribution that formed in the Big Bang. 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 a significant impact on the fate of galaxies as well as the stars and planets within them. The Matthee group investigates the physical mechanisms that determine how galaxies and their constituents form and evolve using observations of the very distant Universe. They use observations from some of the largest telescopes on Earth and in space. They look inside distant galaxies and probe the properties of the young massive stars and their impact on interstellar gas clouds.

Current Projects: Galaxies as tracers and agents of cosmic reionization; The properties of the first stars and black holes in the first galaxies

Jorryt Matthee

Career: Since 2023 Assistant Professor, ISTA
2018–2023 Postdoctoral researcher (Zwicky Fellow), ETH Zurich, Switzerland
2018 PhD, Leiden University, The Netherlands

Modic Group
Thermodynamics of Quantum Materials at the Microscale

Astronomy

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 École Normale Supérieure, Paris, France
2012–2015 CNRS researcher, École Polytechnique, Paris, France
2010–2012 Research Scholar, Princeton University/GFDL, Princeton, USA
2008–2010 Postdoc, Massachusetts Institute of Technology, Cambridge, USA
2008 PhD, New York University, Courant Institute of Mathematical Sciences, New York, USA

Novarino Group
Genetic and Molecular Basis of Neuro-developmental Disorders

Neuroscience

Gaia Novarino studies the genes underlying inherited forms of neuro-developmental 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—from molecular biology to behavior—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; Chromatin remodeling in intellectual disability; Studying convergences and divergences across genetically defined autism disorders; Metabolic pathways in neurodevelopmental disorders

Gaia Novarino

Career: Since 2021 Vice President for Science Education, ISTA
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 architectures from simple building blocks consuming energy: bacteria form colonies, cells reshape, and muscles contract. The general physical principles that lead to those remarkable and robust phenomena remain, however, to be unveiled.

The Palacci group, aka Materiali Molli Lab, 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 Materiali Molli 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 2023 Professor, ISTA
2021–2023 Assistant Professor, ISTA
2021–2023 Adjunct Professor, University of California, San Diego, USA
2020–2021 Associate Professor (with tenure), 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

Pellicciotti Group
Cryosphere and Mountain Hydrosphere

Data Science
Earth Science

Models are a powerful tool to understand the relationships between Earth's climate and surface features. The Pellicciotti group models the interactions of the climate—especially a changing one—and glaciers, snow, and water resources.

The Pellicciotti group is currently investigating the only growing glaciers in the world, those in the Pamir and Karakoram mountains, west of the Himalayas. The goal is to understand the causes of this anomalous state. The Pellicciotti group's research bridges the scales from single glaciers to entire mountain regions—Pellicciotti's fieldwork has taken her from Nepal's Himalayas to Chile's Andes. The group combines data from field research and remote sensing with the application of numerical models and data science to understand the role of the mountain cryosphere in a changing world.

Current Projects: Modeling glacier-climate interactions; Glacier response to a changing climate and high elevation water resources and water security; Green-blue water interactions in high mountain catchments; Debris-covered glaciers and their response to climate; Snow processes and their importance for catchments water balance

Francesca Pellicciotti

Career: Since 2023 Professor, ISTA
Since 2018 Group Leader, Swiss Federal Institute for Forest, Snow and Landscape Research, Switzerland
2017–2022 Associate Professor, Northumbria University, UK
2013–2018 Visiting Scientist, ICIMOD, Kathmandu, Nepal
2007–2014 Senior Researcher, ETH Zurich, Switzerland
2004–2007 Postdoctoral research associate, ETH Zurich, Switzerland
2004 PhD, ETH Zurich, Switzerland

Pieber Group
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, generates no waste, and can be obtained from renewable sources.

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

Current projects: Design of (photo) catalysts; Photoactive ligands; Light-mediated cross-couplings; Light-mediated bond cleavage; Heterogeneous photocatalysis; Chromoselective synthesis

Bartholomäus Pieber

Career: Since 2023 Assistant Professor, ISTA
2020–2023 Lecturer (Dozent), University of Potsdam, Germany
2018–2023 Group Leader at the Max Planck Institute of Colloids and Interfaces, Potsdam, Germany
2022 Visiting Associate, California Institute of Technology, USA
2016–2017 Postdoc, Max Planck Institute of Colloids and Interfaces, Germany
2015 PhD, University of Graz, Austria

Pietrzak Group
Cryptography

Computer Science

The cryptography group works on theoretical and applied cryptography, the science behind information security. Current projects include:

Sustainable cryptocurrencies: Bitcoin is the first decentralized digital currency and the most successful cryptocurrency to date. To achieve security, Bitcoin requires that huge amounts of computing power are constantly wasted. The cryptography group develops more sustainable "Bitcoin-like" blockchains 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 provably 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

Electrons confined to two dimensions can behave in unique and fascinating ways. For example, the quantum mechanical motion of electrons in certain 2D materials can acquire striking collective characters. These emergent strongly correlated electronic states manifest topological order, superconductivity, magnetism, and other electronic orders. The Polshyn Group experimentally explores such novel electronic states and investigates their fundamental properties.

Graphene and other van der Waals (vdW) materials open exciting opportunities to create new strongly correlated 2D electronic systems in which both the strengths and character of the electronic interactions can be tuned. The Polshyn group employs advanced nanofabrication techniques, ultra-low-temperature electronic transport measurements, and scanning probe microscopy to uncover the physics of the correlated electrons harbored in vdW materials. The group's research aims to answer fundamental physics questions regarding exotic electronic states and establish the physics background for conceptually new electronic devices and qubits.

Current Projects: Chern insulators in graphene moiré systems; Probing the mechanisms of superconductivity in graphene heterostructures; Low-temperature scanning probe microscopy

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 aging; 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 the 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 setups 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 2023 Professor, ISTA
2022–2023 Assistant Professor, ISTA
2019–2022 Associate Professor, University College London, UK
2016–2019 Assistant 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, and are the target of about two-thirds of modern drugs. However, membrane proteins, especially large complexes, are challenging to study and are thus underrepresented 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 govern 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 the 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, Université Joseph Fourier, 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 assembly and maturation mechanisms in retroviruses and poxviruses. 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 regulate directional cell movement by adapting the actin cytoskeleton via the intricate interplay of actin filament geometry and the activity of actin 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 image processing methods. Specifically, the group is interested in the conservation and diversity of retroviral capsid assemblies, and the assembly of poxviruses.

Current projects: Cellular structural biology of the actin cytoskeleton and cell migration; Structural assembly mechanisms of retroviral capsid proteins and poxvirus cores; 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 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
Quantum Dynamics and Condensed Matter Theory

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 the 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 the mechanisms of thermalization breakdown. Many-body localized systems present one generic example of thermalization breakdown due to the presence of strong disorder. The Serbyn group is studying 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 conditions. 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. 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 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 function of receptors and ion channels in the brain; Mechanisms of long-term memory formation; Left-right asymmetry of neuronal 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
Microglia-Neuron Interaction

Neuroscience

Identifying brain function has primarily concentrated on how environmental signals are encoded within a complex neuronal network—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, which continuously sense their neuronal environment also beyond just pathogenic insults. We and others have shown that microglia adapt to defined environmental cues and can severely interfere with well-established neuronal circuit elements such as synapse but also extracellular matrix remodeling. Yet, we are only starting to identify these cues, how they drive a microglia response, and which consequences those have on neuronal function in the adult brain. The goal of the Siegert group is to dissect the impact of defined environmental cues like drugs, extracellular matrix, sex, and metabolic insults, and how those cues modulate microglia response to either be beneficial or detrimental to neuronal circuit function and behavior.

Current projects: Disentangle the morph-functional relationship of microglia; How to alter microglia function and pinpoint the consequences on the neuronal network; Microglia-neuron interaction in the human context

Sandra Siegert

Career: since 2023 Professor, ISTA
2015–2023 Assistant Professor, ISTA
2011–2015 Postdoctoral Associate, MIT, Cambridge/MA, USA
2010 PhD, FMI, 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. Principles, which are also 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 2014 Executive Vice President, ISTA
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 today, 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. In particular, they are interested in 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.

The group has three main areas of interest. (1) Plasticity: they use mechanistic models of synaptic plasticity to understand how the brain updates its synaptic connections to learn and adapt to a changing world. (2) Network dynamics and computation: they seek to understand how neuronal networks process and transform sensory inputs, store and manipulate memories, and send motor outputs. (3) Ion channels and single-neuron biophysics: they build detailed biophysical models of single neurons to understand the complex input-output relationships in 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
2014–2020 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 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. 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 questions 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 Fellow, 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, vaporizable 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 information that passes across generations is encoded in the DNA sequence. However, there is increasing appreciation that cells and organisms also inherit information through other mediums, known collectively as epigenetics. 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, particularly to contend 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 *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 Assistant Professor and 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 are thus free and encouraged to work with any research group or SSU. Their ability to devise innovative solutions to research questions makes their support and collaboration critical to the success of numerous projects at ISTA. In addition, their continued presence prevents the loss of knowledge when 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 nine 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

Arcot Jayaram provides comprehensive support to research groups who would like to apply genome engineering technology to generate transgenic rodents. He collaborates with laboratories that perform comparative genomics, especially for genes with broader biological functions.
In the mammalian genome, a gene usually encodes splice-mediated variants of proteins. These proteins perform a function in and around a specific location in the cell; thus, contributing to either a single 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 and the underlying complex biological processes. Representing the transgenic unit of the Pre-Clinical Facility, Arcot Jayaram offers advice to researchers and carries out the entire process of genome engineering. The unit aims to keep up with the latest DNA modification techniques to aid ISTA researchers with the best transgenic models for their research.

Current projects: Mosaic analysis with double markers in rats (Hippenmeyer group); Knock-in mice with epitope tags for *in vivo*-labeling experiments (Shigemoto group); Mosaic-transgenic embryos with different cell types through mES-Cell injection (Novarino group); Knock-in mouse lines to study gene expression pattern (Sixt group)

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, and each studied detail requires a different investigative approach. When faced with such challenges, ISTA researchers can consult Daniel 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 gray 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 his expertise in imaging, optical engineering, automation, and image analysis to ISTA. Working with the Imaging and Optics Facility, he collaborates with scientists from various disciplines to develop innovative solutions for microscopy challenges. This includes designing and constructing new equipment and software.
Microscopy at the cutting edge involves more than the physics of imaging; it requires a holistic approach encompassing automation, system control, and a comprehensive image analysis pipeline. Identifying the most suitable methods for specific projects can be a complex task. Hauschild provides extensive support in areas such as evaluating commercial microscopy equipment and implementing custom modifications in both hardware and software. His assistance ensures that scientists have access to the optimal tools and knowledge necessary for conducting their research effectively.

Current projects: Hardware for sample manipulation, and automation software (CZI); Accessories and protocols to evaluate and maintain microscope performance (CZI); Image analysis and quantification of a wide range of systems: Morphodynamics of immune cells (Sixt); Bacteria in mother machines (Guet); Antibiotics interactions (Guet); Tissue morphogenesis (Heisenberg); NIR spectroscopy (Freunberger); Mesoscopic imaging systems (Sweeney, Cremer)

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

Walter Kaufmann helps ISTA scientists apply advanced electron microscopy to their research in the life sciences.
Kaufmann focuses on the ultrastructural analysis of biological tissues and cells and the high-resolution localization of signaling proteins. He investigates their cell-type specific expression, subcellular localization, and association with specific micro- and nano-domains. He applies state-of-the-art electron microscopy techniques and develops new sample preparation and analysis procedures. Key methodologies performed are pre- and post-embedding immunogold EM, serial section volume TEM, 3D electron tomography, high-pressure freezing plus freeze-substitution and resin embedding (HPF-FS), platinum-replica EM, and freeze-fracture replica labeling. His main current collaborations are within the fields of neurosciences, developmental biology, and the cell biology of plants.

Current projects: Calcium signaling at the chemical synapse in the brain (Jonas, Shigemoto, Siegert groups) and the molecular characterization of neuron extracellular vesicles (Novarino group); Ultrastructural analysis of amoeboid cells crawling in 3D under physical confinement (Sixt group); High-resolution localization of growth hormones and unraveling clathrin-mediated endocytosis in the plant cell (Friml 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**

Peter Koppensteiner
Preclinical Facility

Peter Koppensteiner specializes in electrophysiology and offers experimental and theoretical expertise on a wide range of physiology-related questions. Koppensteiner's methodological repertoire comprises both functional and structural techniques in acute brain slice preparations, such as patch clamp recordings (often in combination with opto- and chemogenetics) and "Flash and Freeze" electron microscopy. Peter supports the development of cutting-edge physiology techniques at ISTA. In particular, he developed a new method for the study of structural and molecular dynamics of neuronal connections, called "Flash and Freeze-fracture" (Shigemoto group). Furthermore, he supported the development of an acute slice single-cell RNA patch sequencing technique to study brain development, called "MADM-Cloneseq" (Hippenmeyer group). Importantly, Peter teaches neurophysiology in theory and practice to ISTA students and instructs students and interns in performing their own electrophysiology experiments.

Current projects: Gap junction physiology (de Bono); Acute slice physiology of human brain organoids (Novarino); Cortical physiology of autism model mice (Novarino); Structural and molecular dynamics of neurotransmitter release using Flash and Freeze-fracture (Shigemoto); Serotonergic modulation and autism-related dysfunction in midbrain neurons (Joesch); GABAergic projections in visual processing (Joesch); Cortical neurodevelopment using MADM-Cloneseq (Hippenmeyer)

Peter Koppensteiner

Career: since 2023 Staff Scientist, ISTA
2017–2023 Postdoc, Shigemoto Group, ISTA
2015–2017 Postdoc, New York University, USA
2015 PhD, Medical University of Vienna

Jack Merrin
Nanofabrication Facility

Microfluidics involves the experimental manipulation of fluids and objects, such as live cells, at small-length scales. Jack Merrin develops novel and innovative systems to study diverse biophysical phenomena 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, an important hormone 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 Wanjiku 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 emotionality, social behavior, and different forms of cognition. Research in behavioral neuroscience has improved our understanding of different human conditions and led to the availability of tools necessary to understand the neurobiological basis of processes such as learning and memory. Muhia collaborates with groups that employ genetic mouse models to understand behavioral changes in various human neurodevelopmental and mental disorders. She also supports researchers interested in combining behavioral paradigms with *in vivo* calcium imaging or optical techniques to understand neuronal ensembles that mediate cognitive functions, including fear memory formation.

Current Projects: Therapeutic potential of 60-Hz light entrainment in fear reduction in a mouse model of PTSD (Siegert group); The impact of context and social make-up on social behavior development in mouse models of ASD (Novarino group); Role of ventral mossy cells and the medial habenula in fear formation (Shigemoto group); *In vivo* calcium imaging to link neural circuit activity and memory formation (Shigemoto group); Understanding the role of synaptotagmins in learning and memory (Jonas group)

Mary Wanjiku 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 specializes in image analysis software development, particularly at the intersection of computer science and biology. Sommer's collaborations include multi-animal behavior analysis with the Novarino and Cremer groups, super-resolution imaging of expanded plant tissue with the Danzl and Friml groups, and a novel method for quantifying cytoskeletal proteins with the Loose group. Additionally, he is working on a tadpole project with the Sweeney group, focusing on deep learning-based body part detection and tracking to study neural locomotor networks in developing *Xenopus* frogs.
In collaboration with the Imaging and Optics Facility (IOF), he introduces advanced bioimage analysis pipelines to a wide range of users.

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); Embryo analysis (Heisenberg group)

Christoph Sommer

Career: since 2017 Staff Scientist, ISTA
2013–2017 Staff Scientist, Institute of Molecular Biotechnology (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 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., CUT&RUN, CUT&TAG to target histone modifications) to sample large numbers of individual cells across multiple regulatory layers. He also works with theory 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 the 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

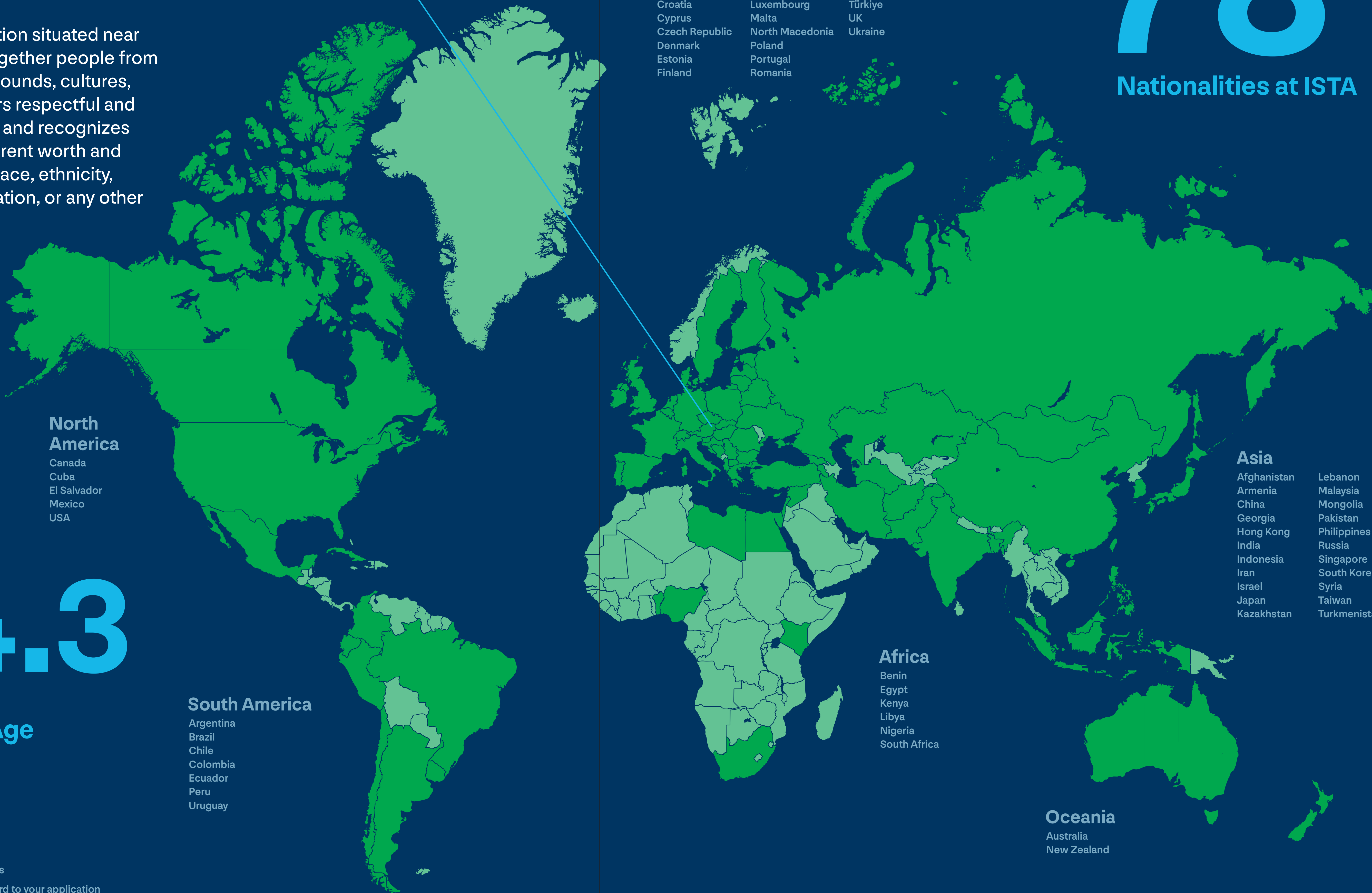
While being an institution situated near Vienna, ISTA brings together people from many different backgrounds, cultures, and mindsets. It fosters respectful and constructive dialogue and recognizes every individual's inherent worth and dignity, regardless of race, ethnicity, religion, sexual orientation,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

ISTA

Klosterneuburg near Vienna, Austria

78

Nationalities at ISTA



Europe

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

North America

Canada
Cuba
El Salvador
Mexico
USA

South America

Argentina
Brazil
Chile
Colombia
Ecuador
Peru
Uruguay

Africa

Benin
Egypt
Kenya
Libya
Nigeria
South Africa

Asia

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

Oceania

Australia
New Zealand

34.3

Average Employee Age

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

Country of Nationality

*Scientic and summer interns throughout 2023, otherwise as of December 31, 2023

Professors & Staff Scientists

As of December 31, 2023

Professors: 74
(without persons on leave)

Female: 17 (23%)
Male: 57 (77%)

Dan Alistarh Distributed Algorithms and Systems
Zhanybek Alpichshev Condensed Matter and Ultrafast Optics
Nick Barton Evolutionary Genetics
Denitsa Baykusheva* Ultrafast Quantum Phases and Spectroscopy
Eva Benková Plant Developmental Biology
Carrie Bernecky RNA-based Gene Regulation
Bernd Bickel Computer Graphics and Digital Fabrication
Jack Bravo* Bacterial Immune Systems
Timothy Browning Analytic Number Theory and its Interfaces
Lisa Bugnet Asterics – Asteroseismology and Stellar Dynamics
Ilaria Caiazzo* Stars and Compact Objects
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
Ylva Götberg Massive Binary Stars
Zoltan Haiman** Black Hole Astrophysics and Cosmology
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
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
Francesco Locatello Causal Learning and Artificial Intelligence
Martin Loose Self-Organization of Protein Systems
Jan Maas Stochastic Analysis
Jorryt Matthee Astrophysics of Galaxies
Alicia Michael* Genome Regulation and Biological Timekeeping
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
Florian Praetorius* Biomolecular Design
Matthew Robinson Medical Genomics
Michael Sammler** Programming Languages and Verification
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
Latha Venkataraman** Single-Molecule Physics and Chemistry
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: 9
(no gender data due to data protection)

Satish Arcot Jayaram Preclinical Facility
Dániel Balázs Lab Support Facility
Robert Hauschild Imaging and Optics Facility
Walter Kaufmann Electron Microscopy Facility
Peter Koppensteiner Preclinical Facility
Jack Merrin Nanofabrication Facility
Mary Wanjiku Muhia Preclinical Facility
Christoph Sommer Imaging and Optics Facility
Jake Yeung Scientific Computing

* joining ISTA in 2024 (see pages 68–70)
** joining ISTA in 2025

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, 2023; percentages are rounded

ISTerns (summer interns): 37

Female: 16 (43%)
Male: 21 (57%)

Scientific Interns: 121
(throughout 2023)

Female: 45 (37%)
Male: 76 (63%)

PhD Students: 345

Female: 137 (40%)
Male: 208 (60%)

Postdocs: 204

Female: 62 (30%)
Male: 142 (70%)

Alumni Network: 651

PhD Students/Graduates: 209
Postdocs: 442
(at least one year spent at ISTA)

Scientific Staff: 156
(Lab Technicians and SSUs)

Female: 91 (58%)
Male: 65 (42%)

Administrative Staff: 266
(incl. Academic Support)
Female: 154 (58%)
Male: 112 (42%)

This year, 32 students completed their PhD, another 4 students completed their master's degree. Together they bring the number of graduates to 195.

PhD Theses

Julia Magdalena Michalska
A versatile toolbox for the comprehensive analysis of nervous tissue organization with light microscopy; Danzl Group

Bettina Zens
Ultrastructural characterization of natively preserved extracellular matrix by cryo-electron tomography; Schur Group

Michael Riedl
Synchronization in collectively moving active matter; Hof Group

Pietro Brighi
Ergodicity breaking in disordered and kinetically constrained quantum many-body systems; Serbyn Group

Laura Burnett
To flee, or not to flee? Using innate defensive behaviours to investigate rapid perceptual decision-making through subcortical circuits in mouse models of autism; Jösch Group

Ana Catarina Lemeshko
Alcarva Pontes Plasticity in the cerebellum: What molecular mechanisms are behind physiological learning; Shigemoto Group

Victoria Pokusaeva
Neural control of optic flow-based navigation in Drosophila melanogaster; Jösch Group

Vladyslav Kravchuk
Structural and mechanistic study of bacterial complex I and its cyanobacterial ortholog; Sazanov Group

Mariano Calcabrini
Nanoparticle-based semiconductor solids: from synthesis to consolidation; Ibáñez Group

Alexandra Magdalena Schauer
Mesendoderm formation in zebrafish gastrulation: The role of extraembryonic tissues; Heisenberg Group

Rishabh Sahu
Cavity quantum electrooptics; Fink Group

Christian Hafner
Inverse Shape Design with Parametric Representations: Kirchhoff Rods and Parametric Surface Models; Bickel Group

Daniel Boocock
Mechanochemical pattern formation across biological scales; Hannezo Group

Laura Bocanegra-Moreno
Epithelial dynamics during mouse neural tube development; Kicheva Group

Elena-Alexandra Peşte
Efficiency and Generalization of Sparse Neural Networks; Lampert Group

Lisa S. Knaus
The metabolism of the developing brain: How large neutral amino acids modulate perinatal neuronal excitability and survival; Novarino Group

Anna Franschitz
Individual and social immunity against viral infections in ants; Cremer Group

Marco Valentini
Mesoscopic phenomena in hybrid semiconductor-superconductor nanodevices. From full-shell nanowires to two-dimensional hole gas in germanium; Katsaros Group

Gemma Puixeu
The Molecular Basis of Sexual Dimorphism. Experimental and Theoretical Characterization of Phenotypic, Transcriptomic and Genetic Patterns of Sex-Specific Adaptation; Vicoso Group

Katarzyna Kuźmicz-Kowalska
Regulation of neural progenitor survival by Shh and BMP in the developing spinal cord; Kicheva Group

Philipp Radler
Spatiotemporal signaling during assembly of the bacterial divisome; Loose Group

Basile Confavreux
Synapseek: Meta-learning synaptic plasticity rules; Vogels Group

Barbara Roos
Boundary Superconductivity in BCS Theory; Seiringer Group

Duc Phan
Resonant microwave spectroscopy of Al-InAs; Higginbotham Group

Đorđe Žikelić
Automated Verification and Control of Infinite State Stochastic Systems; Chatterjee Group

Michelle Yeo
Advances in Efficiency and Privacy in Payment Channel Network Analysis; Pietrzak Group

Nataliia Gnyliukh
Mechanism of Clathrin-coated Vesicle Formation during Endocytosis in Plants; Friml Group

Alice Marveggio
Weak-strong stability and phase-field approximation of interface evolution problems in fluid mechanics and in material sciences; Csicsvari Group

Michael Hennessey
Adaptive mutation in E. coli modulated by luxS; Hof Group

Stefan Sack
Improving variational quantum algorithms: Innovative initialization techniques and extensions to qudit systems ; Serbyn Group

Julian Alexander Stopp
Neutrophils on the Hunt: Migratory Strategies Employed by Neutrophils to Fulfill Their Effector Function; Sixt Group

Louise Arathoon
Investigating inbreeding depression and the self-incompatibility locus of Antirrhinum majus; Barton Group

Master Theses

Kseniia Kirillova
Panoramic functional gradients across the mouse retina; Jösch Group

Mara Julseth
The effect of local population structure on genetic variation at selected loci in the A. majus hybrid zone; Barton Group

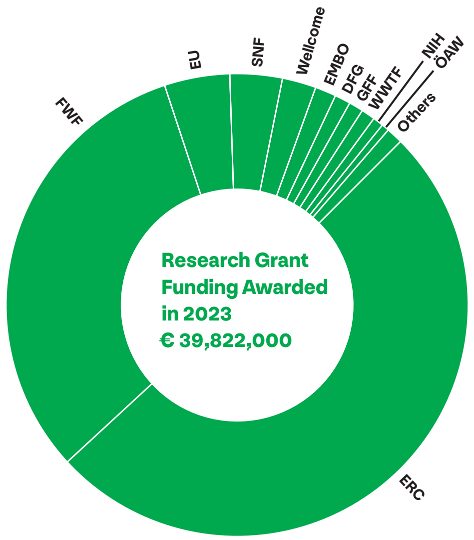
Seyda Köse
Exterior algebra and combinatorics; Wagner Group

Elizabeth Stephenson
Generalizing Medial Axes with Homology Switches; Edelsbrunner Group

Fields of Research

Grants

Active or received third-party funding in 2023; funding amounts are rounded



€ 20,166,000	ERC
€ 12,655,000	FWF
€ 1,820,000	Other EU
€ 1,458,000	SNF
€ 944,000	Wellcome
€ 586,000	EMBO
€ 441,000	DFG
€ 401,000	GFF
€ 386,000	WWTF
€ 293,000	NIH
€ 211,000	ÖAW

€ 461,000	**Others, including:**
€ 120,000	AERI
€ 103,000	TSF
€ 100,000	EAS
€ 45,000	Minerva Stiftung
€ 44,000	JSPS
€ 27,000	FFG
€ 13,000	OeAD
€ 9,000	Google

Abbreviations

AERI Alistore European Research Institute
BIF Boehringer Ingelheim Fonds
BMBWF Bundesministerium für Bildung, Wissenschaft und Forschung
BBRF Brain Behaviour Research Foundation
CZI Chan Zuckerberg Initiative
DFG Deutsche Forschungsgemeinschaft
DOE Department of Energy (USA)
EAS European Astronomical Society
EIC European Innovation Council
EMBO European Molecular Biology Organization
ERC European Research Council
– **AdG** Advanced Grant
– **CoG** Consolidator Grant
– **PoC** Proof of Concept Grant
– **StG** Starting Grant
– **SyG** Synergy Grant
FEBS Federation of European Biochemical Societies
FFG Forschungsförderungsgesellschaft
FWF Fonds zur Förderung der wissenschaftlichen Forschung
– **COE** Cluster of Excellence
– **SFB** Spezialforschungsbereich
GFF Gesellschaft für Forschungsförderung Niederösterreich
HE Horizon Europe
HFSP Human Frontier Science Program
HRSM Hochschulraum-Strukturmittel-Projekte
H2020 Horizon 2020*
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 Österreichischer Austauschdienst
ÖAW Österreichische Akademie der Wissenschaften
PRACE Partnership for Advanced Computing in Europe
SNF Schweizer Nationalfonds
TSF Takenaka Scholarship Foundation
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, H2020 ERC StG, €1,494,000; 3/19-2/24

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

FastML: Efficient and Cost-Effective Distributed Machine Learning, HE ERC PoC, €150,000; 5/24-10/25

Alpichshev Group

Nonlinear THz spectroscopy of quantum critical materials, FWF SFB, €251,000; 1/23-12/26

Barton Group

The maintenance of alternative adaptive peaks in snapdragons, FWF Stand-alone, €404,000; 3/20-2/24

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

Dynamics of Wolbachia Spread in *Rhagoletis cerasi*, FWF Stand-alone (Partner, Awardee: Christian Stauffer), €84,000; 6/22-5/26

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

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

Polygenic Adaptation in a Metapopulation, ÖAW DOC, €77,000; 9/22-1/24

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

Understanding Polygenic Adaptation, FWF SFB, €370,000; 1/24-12/27

Benková Group

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

Post-Translational Control of CRFs in Plant N Signalling, 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 Cooperation RIA, €375,000; 10/22-9/26

Phototropism in Plants, FFG Femtech, €8,000; 7/23-1/24

Bernecky Group

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

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

Bickel Group

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

Browning Group

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, H2020 ERC CoG, €1,998,000; 1/21-12/25

Graphical Games, FFG Femtech, €8,000; 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; 1/23-12/25

Time-resolved simulations of ultrafast phenoMena in quantum matErialS, HE MSCA DN, €270,000; 3/24-2/28

ab initio PRediction Of MaterIal SynthEsis, HE ERC StG, €1,497,000; 4/24-3/29

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

The role of autonomous nervous regulation on hippocampal-cortical circuit dynamics and memory reactivation, BBRF NARSAD Young Investigator Grant, €30,000; 1/22-1/23

Danzl Group

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

High content imaging to decode human immune cell interactions in health and allergic disease, NFB Life Science, €279,000; 12/19-11/23

Studying Organelle Structure and Function at Nanoscale Resolution with Expansion Microscopy, ÖAW DOC, €77,000; 8/21-7/23

CryoMinflux-guided in-situ visual proteomics and structure determination, CZI Visual Proteomics, €415,000; 8/21-12/25

de Bono Group

Molecular mechanisms of neural circuit function, Wellcome Trust Investigator Award, €1,223,000; 10/19-3/24

Roles of MALT-1 and NFKI-1/IKBzeta in IL-17 neuromodulation, FWF Meitner, €178,000; 2/22-1/25

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

Molecular Dynamic of Neurons during *C. elegans* Lifespan, HE MSCA DN, €270,000; 9/23-8/27

FFG Praktika für Schüler, €1,200; 8/23-8/23

Edelsbrunner Group

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

FWF Wittgenstein Award - Herbert Edelsbrunner, €1,500,000; 7/19-6/24

Persistent Homology, Algorithms and Stochastic Geometry, FWF SFB, €296,000; 10/20-9/24

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

Erdös Group

Random matrices beyond Wigner-Dyson-Mehta, H2020 ERC AdG, €1,912,000; 10/21-9/26

Feng Group

Establishment, modulation and inheritance of sexual lineage specific DNA methylation in plants, H2020 ERC StG, €180,000; 1/23-5/24

Auxin Epigenetics, FFG Femtech, €8,000; 11/23-3/24

EMBO Young Investigator Program - Xiao Feng, €10,000; 5/23-12/25

JSPS Young Scientists, €44,000; 9/23-3/25

Mechanisms and biological functions of H3K27me3 reprogramming in plant microspores, HE ERC CoG, €2,000,000; 6/24-5/29

Fink Group

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

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

Cavity Quantum Electro Optics: Microwave photonics with non-classical states, HE ERC CoG, €1,999,000; 9/23-8/28

Quantum Information Systems Beyond Classical Capabilities / P5- Integration of Superconducting Quantum Circuits, FWF SFB, €498,000; 3/23-2/27

Open Superconducting Quantum Computers (OpenSuperQPlus), HE Clusters 4-Digital, €531,000; 3/23-8/26

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, HE ERC PoC, €150,000; 5/22-10/23

Multifunktionales Energiespeichermaterial auf Basis von flüssigem Phosphor und Phosphorsäureester-Derivaten, FFG Energieforschung, €9,000; 9/22-11/23

Electrode development for novel all-organic redox flow batteries, GFF Grundlagenforschung, €131,000; 9/23-8/26

Reactive oxygen species at TM oxide intercalation materials, Alistore PhD, €120,000; 12/23-11/26

Singlet oxygen in non-aqueous redox chemistries, FWF Stand-alone, €400,000; 5/24-4/27

Friml Group

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

Characterization of a novel gene required for auxin canalization, FWF ESPRIT, €294,000; 12/22-11/25

Guanylate cyclase activity of TIR1/AFBs auxin receptors, FWF Stand-alone, €422,000; 8/23-7/27

Molecular mechanism underlying auxin regulation of autophagy in plants, EMBO PF, €144,000; 9/23-8/25

TIR1-generated cAMP as second messenger in transcriptional auxin signaling, EMBO PF, €144,000; 1/24-12/25

Goodrich Group

Dynamically reconfigurable self-assembly with triangular DNA-origami bricks, GFF FTI, €270,000; 3/24-2/27

Guet Group

CyberCircuits: Cybergenetic circuits to test composability of gene networks, FWF International program, €268,000; 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; 8/21-9/23

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

Non-canonical antibiotic interactions, FWF ESPRIT, €324,000; 3/23-2/26

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

Monitoring bacteriophage infection in bacterial biofilms, OEAD WTZ, €7,000; 1/23-12/24

Hannezo Group

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

EMBO Young Investigator Program - Edouard Hannezo, €15,000; 1/20-12/23

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

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

A mechano-chemical theory for stem cell fate decisions in organoid development, EMBO PD, €139,000; 2/23-1/25

Multiscale dynamics of mammary gland remodeling, FWF International program, €399,000; 1/23-1/27

FFG Praktika für Schüler, €1,200; 7/23-7/23

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

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

Tissue morphogenesis driven by feedback regulations between fluidization and kinase activation, JSPS ORF, €100,000; 4/21-1/23

Dissecting the mechanisms underlying cytoplasm reorganization and embryo patterning in ascidians, HFSP LTF, €194,000; 7/21-12/23

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

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

Mechanosensitive signaling activation in the crosstalk between mechanical force and tissue fluidity, EMBO PD, €139,000; 2/23-1/25

Metabolic regulation of cell cleavages in early embryogenesis, HE MSCA PF, €199,000; 3/24-2/26

Henzinger_M Group

FWF Wittgenstein Award - Monika Henzinger, €1,500,000; 3/23-2/28

The design and evaluation of modern fully dynamic data structures, H2020 ERC AdG, €2,192,000; 3/23-12/26

Fast Algorithms for a Reactive Network Layer, FWF Stand-alone, €173,000; 3/23-9/24

Static and Dynamic Hierarchical Graph Decompositions, FWF International program, €145,000; 3/23-2/26

Henzinger_T Group

Vigilant Algorithmic Monitoring of Software, H2020 ERC AdG, €2,451,000; 1/22-12/26

Interface Theory for Security and Privacy, FWF SFB, €284,000; 1/23-12/26

Higginbotham Group

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

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

Hybrids of correlated materials and superconducting circuits, FWF SFB, €507,000; 1/23-12/26

Hippenmeyer Group

Molecular Mechanisms of Neural Stem Cell Lineage Progression, FWF SFB, €373,000; 3/20-2/24

3D-Animationsvideo und Virtual Reality-App zur Anwendung der "Mosaik-Analyse mit Doppel-Markern in der Stammzellforschung", FWF Wissenschaftskommunikation, €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

Role of cell lineage in generating cell-type diversity in developing neocortex, EMBO PF, €144,000; 1/24-12/25

Molecular Mechanisms of Neural Stem Cell Lineage Progression, FWF SFB, €413,000; 3/24-2/28

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; 1/20-12/23

Hydrodynamic stability of pulsatile flow of complex fluids, FWF International program, €319,000; 1/24-12/26

Hosten Group

A quantum hybrid of atoms and milligram-scale pendulums: towards gravitational quantum mechanics, HE ERC CoG, €2,000,000; 6/23-5/28

Tunable ultra-low noise lasers of the future, FFG Spin-off (as host with Fellow Fritz Diorico), €493,000; 1/23-9/24

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

Solar-Light-Driven Photoelectrochemical System, OEAD WTZ, €8,000; 1/21-10/23

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

Jonas Group

FWF Wittgenstein Award - Peter Jonas, €1,500,000; 10/17-3/23

Intercellular Hippocampal Attractor Dynamics, FWF Firnberg, €239,000; 9/19-9/23

Synaptic computations of the hippocampal CA3 circuitry, H2020 MSCA IF, €174,000; 1/22-12/23

Mechanisms of GABA release in hippocampal circuits, FWF Stand-alone, €596,000; 2/23-1/27

Synaptic networks of human brain, FWF PIP, €400,000; 6/24-5/28

Jösch Group

Evolution of Sensorimotor Transformation Across Diptera, DFG SPP (grant received together with Fyodor Kondrashov), €724,000; 3/21-2/27

Determining the Molecular Logic of Direction-Selective Wiring Program, BIF PhD fellowship, €59,000; 1/22-10/24

Action Selection in the Midbrain: Neuromodulation of Visuomotor Senses, HE ERC CoG, €1,998,000; 10/23-9/28

Kaloshin Group

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

Katsaros Group

Towards scalable hut wire quantum devices, FWF Stand-alone, €407,000; 10/19-9/23

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

Conventional and unconventional topological superconductors, FWF SFB, €507,000; 1/23-12/26

Merging spin and superconducting qubits in planar Ge, FWF Stand-alone, €399,000; 1/23-12/26

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

Integrated GermaNIum quanTum tEchnology, HE Cooperation RIA, €260,000; 7/22-6/25

Topologically Protected and Scalable Quantum Bits, H2020 Cooperation FET-Open, €504,000; 12/19-8/23

Quantum bits with Kitaev Transmons, HE EIC Pathfinder Challenges, €697,000; 10/23-9/27

Kicheva Group

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

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

The role of mechanosensitive feedback on the regulation of tissue growth in the developing neural tube, EMBO LTF, €139,000; 2/23-2/25

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

Klajn Group

Dissipative self-assembly in synthetic systems: Towards life-like materials, H2020 ERC CoG, €582,000; 8/23-12/24

Integrating molecular photo switches with pH-feedback mechanisms, Minerva Stiftung ARCHES Award, €45,000; 8/23-12/24

Kokoris-Kogias Group

Secure Network and Hardware for Efficient Blockchains, FWF SFB, €284,000; 1/23-12/26

SCALE2: SeCure, privAte, and interoperabLe layEr 2, WWTF ICT22, €284,000; 6/23-5/27

Kolmogorov Group

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

Kwan Group

Randomness and structure in combinatorics, HE ERC StG, €1,344,000; 5/23-4/28

Lemeshko Group

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

Non-equilibrium Field Theory of Molecular Rotations, HE MSCA PF, €199,000; 2/23-1/25

Coherent Optical Metrology Beyond Electric-Dipole-Allowed Transitions, FWF SFB, €713,000; 3/24-2/28

Locatello Group

Discovering object-centric relations with foundation models, Google Research, €9,000; 1/24-12/25

Loose Group

EMBO Young Investigator Program - Martin Loose, €15,000; 1/20-12/23

Synthetic and structural biology of Rab GTPase networks, HE ERC CoG, €1,929,000; 1/23-12/27

In vitro reconstitution of bacterial cell division, FWF Stand-alone, €389,000; 9/21-8/24

Deciphering lipid-transport mechanism at inter-organelle membrane contact sites during autophagosome biogenesis, EMBO PF, €144,000; 4/24-4/26

Maas Group

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

Differential calculus and 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

Matthee Group

Young galaxies as tracers and agents of cosmic reionization, HE ERC StG, €1,498,000; 9/23-8/28

Witnessing galaxies' birth with JWST spectroscopy, MERAC Prize, €100,000; 9/23-8/25

Modic Group

Unraveling the mysteries of 1T-TaS_2, FWF Stand-alone, €404,000; 4/22-3/25

Scale-invariance in entangled quantum spin systems, FWF SFB, €277,000; 1/23-12/26

A new probe of multipole physics in Pr-based compounds, FWF ESPRIT, €301,000; 5/22-4/25

Pinning down the ground state of $Tb_2Ti_2O_7$ using resonant torsion magnetometry, ÖAW DOC, €77,000; 7/22-6/24

Gaining leverage with spin liquids and superconductors, HE ERC StG, €2,325,000; 5/23-4/28

Mondelli Group

Prix Lopez-Loreta 2019 - Marco Mondelli, €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, H2020 ERC StG, €719,000; 9/21-5/24

Novarino Group

Molecular Drug Targets, FWF DK, €202,000; 3/19-2/24

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

Stem Cell Modulation in Neural Development and Regeneration, FWF SFB, €375,000; 3/20-2/24

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

Multi-level analysis of negative valence in ASD models, FWF Forschungsgruppen, €616,000; 4/22-3/26

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

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

FFG Talente-Praktikum, €1,200; 7/23-8/23

FFG Talente-Praktikum, €1,200; 7/23-8/23

Palacci Group

Emergent Phenomena in Collection of Autonomous Spinning Microgears Guided by Light, ARO Basic Research Award, €264,000; 11/22-11/24

Emergent Behavior in Spinning Active Matter, FWF Stand-alone, €400,000; 2/22-1/25

VULCAN: matter, powered from within, HE ERC CoG, €1,965,000; 9/23-8/28

Pellicciotti Group

EPIC - ExPloring the ecohydrological Impacts of a changing Cryosphere in the Peruvian Andes, HE MSCA PF, €184,000; 1/24-12/25

FFG Praktika für Schüler, €1,200; 7/23-7/23

Takenaka Scholarship Foundation Study Abroad Scholarship, €103,000; 7/23-7/28

Resolving the thickness of debris on Earth's glaciers and its rate of change, SNF Project Funding-II, €686,000; 7/23-2/26

Glacier retreat and their impact on mountain ecosystems and agriculture in Peru, SNSF SNF-SPIRIT, €289,000; 5/23-1/26

MegaWat: Megadroughts in the Water towers of Europe, FWF International program, €398,000; 4/24-3/27

Pieber Group

Merging Photocatalysis with Transition Metal Catalysis in a Single, Modular Material, DFG Sachbeihilfe, €60,000; 6/23-1/24

Auxin conversion, FFG Praktika für Schüler, €1,200; 8/23-9/23

Pietrzak Group

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

Cross-Layer Security for Blockchain Consensus, FWF SFB, €284,000; 1/23-12/26

Polshyn Group

Orbital Cherm Insulators in van der Waals Moiré Systems, HE ERC StG, €1,832,000; 7/24-6/29

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; 1/22-12/24

Non-Equilibrium Protein Assembly: from Building Blocks to Biological Machines, H2020 ERC StG, €1,055,000; 1/22-9/24

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

UCL Studentship Fellowship, €33,000; 1/22-2/24

UCL Studentship Fellowship, €28,000; 1/22-6/23

EMBO Young Investigator Program - Andela Saric, €15,000; 1/22-12/24

How do you build a wall? Mechanistic principles of bacterial division septum building, Wellcome Trust Discovery Award, €944,000; 1/24-1/32

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, H2020 ERC AdG, €1,781,000; 9/21-8/26

FWF Wittgenstein Award (National Research Partner, Awardee Michael Wagner), €152,000; 7/21-6/23

Mitochondrial Complex I as a Target for Neuroprotection in AD, NIH R01, €293,000; 9/22-8/25

Schanda Group

AlloSpace: The emergence and mechanisms of allostery, FWF International program, €303,000; 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

Structure and mechanism of the mitochondrial MIM insertase, FWF International program, €372,000; 5/23-4/26

Protein motion & NMR, FFG Femtech, €3,000; 8/23-9/23

Exploring protein dynamics by solid-state MAS NMR through specific labeling approaches, ÖAW DOC, €117,000; 9/23-2/26

Schur Group

Structure and isoform diversity of the Arp2/3 complex, FWF Stand-alone, €417,000; 7/20-6/23

Structural characterization of Spumavirus capsid assemblies to understand conserved ortervirales assembly mechanisms, ÖAW DOC, €123,000; 10/20-2/24

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

CryoMinflux-guided in-situ visual proteomics and structure determination, CZI Visual Proteomics, €407,000; 8/21-12/25

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

EMBO Young Investigator Program - Florian Schur, €15,000; 1/22-12/25

A molecular atlas of Actin filament IDentities in the cell motility machinery, HE ERC StG, €1,500,000; 4/23-3/28

In Situ Structure Determination of Actin-binding Proteins Through a Novel Cryo-electron Microscopy Workflow, HE MSCA PF, €199,000; 4/23-6/23

Insights into Mitochondrial Dynamics using CSTET, FWF Schrödinger, €86,000; 7/23-6/24

In Situ Actin Structures via Hybrid Cryo-electron Microscopy, FWF ESPRIT, €316,000; 7/23-6/26

Seiringer Group

Mathematical Challenges in BCS Theory of Superconductivity, FWF International program, €172,000; 3/23-2/27

Serbyn Group

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

Probing topology in circuits and quantum materials, FWF SFB, €363,000; 1/23-12/26

IBM PhD Fellowship Award, €37,000; 9/22-5/23

Shigemoto Group

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; 1/21-12/24

Structural & functional basis of presynaptic plasticity, FWF International program, €396,000; 1/23-12/25

LGI1 antibody-induced pathophysiology in synapses, FWF International program, €285,000; 7/23-6/26

Siegert Group

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

Dissecting the morpho-functional relationship of microglia, FWF Stand-alone, €424,000; 9/23-8/26

60-Hz light entrainment to unlock mental health conditions, HE ERC PoC, €150,000; 3/24-8/25

Sixt Group

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

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

Pushing from within: Control of cell shape, integrity and motility by cytoskeletal pushing forces, HE ERC SyG, €2,516,000; 5/23-4/29

The role of polysialic acid in T cell immunity, FWF International program, €324,000; 4/23-3/26

ImMuNet: Decoding the Immunological Microtubule Network, SNF Sinergia, €483,000; 10/23-9/27

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 Standard 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

Swim-to-limb transition: cell type to connection diversity, FWF SFB, €412,000; 3/24-4/28

Tkačik Group

Can evolution minimize spurious signaling crosstalk to reach optimal performance?, HFSP Program grant, €269,000; 12/18-11/23

Efficient coding with biophysical realism, FWF Stand-alone, €362,000; 12/20-5/24

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

Collective behaviour of cells in pancreatic Islets of Langerhans, ÖAW DOC, €95,000; 10/23-9/25

Transcription in 4D: the dynamic interplay between chromatin architecture and gene expression in developing pseudo-embryos, HE ERC Synergy Grant, €2,123,000; 5/24-4/30

Understanding pancreas biology with AI/ML, WWTF, €386,000; 5/24-4/28

Vicoso Group

Sexual conflict: resolution, constraints and biomedical implications, ÖAW DOC, €119,000; 8/20-7/23

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

The hijacking 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; 8/20-1/26

Wagner Group

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

Application of Mit Quincke Rollers mixen, FWF ESPRIT, €294,000; 12/22-8/23

Wojtan Group

Computational Discovery of Numerical Algorithms for Animation and Simulation of Natural Phenomena, HE ERC CoG, €1,937,000; 6/22-5/27

Zilberman Group

Quantitative analysis of DNA methylation maintenance with chromatin, H2020 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

FWF "Clusters of Excellence" Program

Materials for Energy Conversion and Storage (ISTA Groups: Cheng; Freunberger), FWF COE, €1,649,000; 10/23-9/28

Quantum Science Austria (ISTA Groups: Fink; Serbyn), FWF COE, €2,310,000; 10/23-9/28

Microbiomes Drive Planetary Health (ISTA Groups: Sazanov), FWF COE, €630,000; 10/23-9/28

Admin & SSUs

Imaging & Optics Facility

Tools for automation and feedback microscopy, CZI Imaging Scientist, €941,000; 12/20-11/25

Drift Correction in Time-lapse Imaging with napari-correct-drift, CZI napari Plugin Foundations, €23,000; 11/22-10/23

ISTA Postdoctoral Fellowships

ISTplus - Postdoctoral Fellowships, H2020 MSCA Co-fund, €4,590,000; 7/17-6/23

NOMIS Postdoctoral Fellowship Program, €1,800,000; 2/20-1/25

IST-BRIDGE: International postdoctoral program, H2020 MSCA Co-fund, €4,598,000; 11/21-10/26

ISTA Scientific Activities

ERASMUS+ Staff Mobility GA5, €25,000; 6/20-5/23

ERASMUS+ Staff Mobility GA6, €13,000; 9/21-10/23

ERASMUS+ Staff Mobility GA7, €14,000; 6/22-7/24

ERASMUS+ Staff Mobility GA8, €13,000; 6/23-7/25

Library

AT2OA2 – Austrian Transition to Open Access Two, BMBWF, €12,000; 1/21-12/24

Science Education

#STEMLooksLikeMe - Fotoausstellung über MINT-Rolemodels für Schülerinnen, Frauenprojektförderungen BKA, €94,000; 11/22-12/23

KinderUni, OeAD, €65,000; 1/23-12/23

Sommercampus for students, OeAD and Land NÖ, €50,000; 8/23

Neuroscience Academy, Land NÖ, €190,000; 10/23-8/25

Science classes & science afternoons, Land NÖ, €15,000; 9/23-12/23

TWIST Fellows & Tech Transfer

Compact ultra-low frequency noise and continuously tunable lasers, FFG Spin-off fellowship, €493,000; 4/23-9/24

Publications

Joint publications involving several groups are listed multiple times

Alistarh Group

Aksenov V, Alistarh D-A, Drozdova A, Mohtashami A. 2023. **The splay-list: A distribution-adaptive concurrent skip-list.** Distributed Computing. 36, 395–418.

Alistarh D-A, Ellen F, Rybicki J. 2023. **Wait-free approximate agreement on graphs.** Theoretical Computer Science. 948(2), 113733.

Alistarh D-A, Aspnes J, Ellen F, Gelashvili R, Zhu L. 2023. **Why extension-based proofs fail.** SIAM Journal on Computing. 52(4), 913–944.

Beznosikov A, Horvath S, Richtarik P, Safaryan M. 2023. **On biased compression for distributed learning.** Journal of Machine Learning Research. 24, 1–50.

Fedorov A, Hashemi D, Nadiradze G, Alistarh D-A. 2023. **Provably-efficient and internally-deterministic parallel Union-Find.** Proceedings of the 35th ACM Symposium on Parallelism in Algorithms and Architectures. SPAA: Symposium on Parallelism in Algorithms and Architectures, 261–271.

Frantar E, Alistarh D-A. 2023. **SparseGPT: Massive language models can be accurately pruned in one-shot.** Proceedings of the 40th International Conference on Machine Learning. ICML: International Conference on Machine Learning, PMLR, vol. 202, 10323–10337.

Iofinova EB, Peste E-A, Alistarh D-A. 2023. **Bias in pruned vision models: In-depth analysis and countermeasures.** 2023 IEEE/CVF Conference on Computer Vision and Pattern Recognition. CVPR: Conference on Computer Vision and Pattern Recognition, 24364–24373.

Koval N, Alistarh D-A, Elizarov R. 2023. **Fast and scalable channels in Kotlin Coroutines.** Proceedings of the ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming. PPoPP: Sympopsium on Principles and Practice of Parallel Programming, 107–118.

Koval N, Khalanskiy D, Alistarh D-A. 2023. **CQS: A formally-verified framework for fair and abortable synchronization.** Proceedings of the ACM on Programming Languages. 7, 116.

Koval N, Fedorov A, Sokolova M, Tsitelov D, Alistarh D-A. 2023. **Lincheck: A practical framework for testing concurrent data structures on JVM.** 35th International Conference on Computer Aided Verification . CAV: Computer Aided Verification, LNCS, vol. 13964, 156–169.

Markov I, Vladu A, Guo Q, Alistarh D-A. 2023. **Quantized distributed training of large models with convergence guarantees.** Proceedings of the 40th International Conference on Machine Learning. ICML: International Conference on Machine Learning, PMLR, vol. 202, 24020–24044.

Nikdan M, Pegolotti T, Iofinova EB, Kurtic E, Alistarh D-A. 2023. **SparseProp: Efficient sparse backpropagation for faster training of neural networks at the edge.** Proceedings of the 40th International Conference on Machine Learning. ICML: International Conference on Machine Learning, PMLR, vol. 202, 26215–26227.

Shevchenko A, Kögler K, Hassani H, Mondelli M. 2023. **Fundamental limits of two-layer autoencoders, and achieving them with gradient methods.** Proceedings of the 40th International Conference on Machine Learning. ICML: International Conference on Machine Learning, PMLR, vol. 202, 31151–31209.

Alpichshev Group

Lorenc D, Alpichshev Z. 2023. **Mid-infrared Kerr index evaluation via cross-phase modulation with a near-infrared probe beam.** Applied Physics Letters. 123(9), 091104.

Volosniev A, Shiva Kumar A, Lorenc D, Ashourishokri Y, Zhumekenov AA, Bakr OM, Lemeshko M, Alpichshev Z. 2023. **Spin-electric coupling in lead halide perovskites.** Physical Review Letters. 130(10), 106901.

Volosniev A, Shiva Kumar A, Lorenc D, Ashourishokri Y, Zhumekenov A, Bakr OM, Lemeshko M, Alpichshev Z. 2023. **Effective model for studying optical properties of lead halide perovskites.** Physical Review B. 107(12), 125201.

Wei Y, Volosniev A, Lorenc D, Zhumekenov AA, Bakr OM, Lemeshko M, Alpichshev Z. 2023. **Bond polarizability as a probe of local crystal fields in hybrid lead-halide perovskites.** The Journal of Physical Chemistry Letters. 14(27), 6309–6314.

Barton Group

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Bolnick DI, Hund AK, Nosil P, Peng F, Ravinet M, Stankowski S, Subramanian S, Wolf JBW, Yukilevich R. 2023. **A multivariate view of the speciation continuum.** Evolution: International journal of organic evolution. 77(1), 318–328.

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Lucek K, Giménez MD, Joron M, Rafajlović M, Searle JB, Walden N, Westram AM, Faria R. 2023. **The impact of chromosomal rearrangements in speciation: From micro- to macroevolution.** Cold Spring Harbor Perspectives in Biology. 15(11), a041447.

Puixeu Sala G, Macon A, Vicoso B. 2023. **Sex-specific estimation of cis and trans regulation of gene expression in heads and gonads of *Drosophila melanogaster*.** G3: Genes, Genomes, Genetics. 13(8).

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Stankowski S, Zagrodzka ZB, Galindo J, Montaño-Rendón M, Faria R, Mikhailova N, Blakeslee AMH, Arnason E, Broquet T, Morales HE, Grahame JW, Westram AM, Johannesson K, Butlin RK. 2023. **Whole-genome phylogeography of the intertidal snail *Littorina saxatilis*.** Evolutionary Journal of the Linnean Society. 2(1), kzad002.

Benkova Group

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Higashi T, Stephenson RE, Schwayer C, Huljev K, Higashi AY, Heisenberg C-PJ, Chiba H, Miller AL. 2023. **ZnUMBA - a live imaging method to detect local barrier breaches.** Journal of Cell Science. 136(15), jcs260668.

Bickel Group

Chen B, Jindal A, Piovarci M, Wang C, Seidel HP, Didyk P, Myszkowski K, Serrano A, Mantiuk RK. 2023. **The effect of display capabilities on the gloss consistency between real and virtual objects.** Proceedings of the SIGGRAPH Asia 2023 Conference. SIGGRAPH: Computer Graphics and Interactive Techniques Conference, 90.

Condor J, Piovarci M, Bickel B, Didyk P. 2023. **Gloss-aware color correction for 3D printing.** SIGGRAPH '23 Conference Proceedings. SIGGRAPH: Computer Graphics and Interactive Techniques Conference, 21.

Freire M, Bhargava M, Schreck C, Hugron P-A, Bickel B, Lefebvre S. 2023. **PCBend: Light up your 3D shapes with foldable circuit boards.** Transactions on Graphics. 42(4), 142.

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Zhong F, Xu Y, Zhao H, Lu L. 2023. **As-Continuous-As-Possible extrusion-based fabrication of surface models.** ACM Transactions on Graphics. 42(3), 26.

Browning Group

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Bugnet Group

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Chatterjee Group

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Bastankhah M, Chatterjee K, Maddah-Ali MA, Schmid S, Svoboda J, Yeo MX. 2023. **R2: Boosting liquidity in payment channel networks with online admission control.** 27th International Conference on Financial Cryptography and Data Security. FC: Financial Cryptography and Data Security, LNCS, vol. 13950, 309–325.

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Imaging & Optics Facility

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Jonas Group

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Jösch Group

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Loose Group

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Novarino Group

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Šarić Group

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Schanda Group

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Seiringer Group

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Shigemoto Group

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Siegert Group

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Vicoso Group

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Awards

Scientific Awards and Distinctions 2023
(selection)

Austrian Cross of Honor for Science and Art
Monika Henzinger

ERC Starting Grant
Bingqing Cheng, Hryhoriy Polshyn, Florian Praetorius

ERC Consolidator Grant
Johannes Fink, Onur Hosten, Maximilian Jösch, Jérémie Palacci, Xiaoqi Feng

ERC Synergy Grant
Gašper Tkačik

ERC Proof of Concept Grant
Dan Alistarh, Sandra Siegert

Erwin Schrödinger Prize
Robert Seiringer

Lower Austrian Science Award
Stefan Freunberger,
Leonid Sazanov, Maksym Serbyn

ISTA Internal Awards 2023

Outstanding Scientific Achievement
Djordje Zikelic, fromer PhD student Chatterjee Group
Mathias Lechner, former PhD student Henzinger Group

Outstanding Scientific Support
Ariana Macon, Research Technician, Vicoso Group

Outstanding Administrative Support
Eva Baghai, Office of the President
Christine Fancoise, Assistant to Professors

Outstanding PhD Thesis
Morris Brooks, Seiringer Group
Rishabh Sahu, Fink Group

Alumni Award
Alexander Kolesnikov, former PhD student Lampert Group

Golden Chalk Award for Excellence in Teaching
Tim Vogels

Golden Sponge Award for Excellent Teaching Assistance
Haralds Baunis
Ece Sönmez

Events

Scientific Conferences, Workshops, and Symposia (selection)

March 3
Development and Stem Cells Regional Meeting (DevStem) 2023
The symposium offers talks, poster sessions, and the opportunity to meet developmental and stem cell biologists.

April 3–6
HQT 2023 & Germanium day
Workshop at the intersection between spin qubits, hybrid semiconductor-superconductor devices, and superconducting circuits/qubits.

May 2–5
NMR Symposium and Workshop 2023
Symposium to bring together established scientists and young researchers working on Nuclear Magnetic Resonance with a focus on biological systems.

July 3–7
NaNaX10
Nanoscience with Nanocrystals Conference brings together scientists of different research disciplines active in the fields of nanoscience and nanotechnology.

October 2–6
Summer School 2023 of the SFB Q-M&S
The summer school aims to bridge the fields of correlated quantum materials and solid-state quantum systems and is a collaborative research project hosted at four institutions in Austria and Germany.

Outreach and Science Education Events (selection)

February 22
Science Education Day
Science teachers meet scientists on the ISTA campus.

June 4
Open Campus
ISTA opens its doors to visitors on the annual Open Campus Day—a big science party for the whole family.

July 31 – August 18
Sommercampus
Children become researchers, carry out exciting experiments, and get to know scientists at ISTA.

August 22–24
Fakebusters & Neuroscience Bootcamp
High school students learn to recognize the difference between reliable scientific information and fake news and study the capabilities of the human brain.

October 19
Young Science Congress
Students, teachers, and scientists explore science through workshops, lectures, experimental and hands-on activities.

November 8
WoMen in Science
Power relations and awareness of culture in academia.

November 9
Young Scientist Symposium 2023
Organized by ISTA's PhD Students and Postdocs, the symposium is dedicated to in-depth explorations of Artificial Intelligence (AI) and computational research, across the domains of biology, physics, mathematics, chemistry, neuroscience, and computer science.

December 21
VISTA Christmas Science Show
Science show with spectacular experiments and answers to scientific questions.

Public Lectures

March 14
Gyorgy Buzsaki (**NYU**)
ISTA Lecture
"Ways to think about the brain: Emergence of cognition from action"

September 28
Alena Buyx (**TUM**)
ISTA Science & Society Lecture
"Between hope and hype – ethical aspects of generative AI"

December 13
Franz Essl (**University of Vienna**)
ISTA Lecture
"The global re-shuffling of species"

Institute Colloquia

January 16
Ann McDermott (**Columbia University**)
Signaling in Biological Systems-Insights from NMR

January 23
Zvonimir Dogic (**UC Santa Barbara**)
Assembly and disassembly of colloidal vesicles

March 27
Erwin Frey (**Ludwig Maximilian University of Munich**)
Self-organisation of proteins in cells

May 22
Isil Dillig (**University of Texas at Austin**)
Program synthesis across the software stack

June 19
Steven Skiena (**Stony Brook University**)
Word and graph embeddings for machine learning

September 25
Vanessa Wood (**ETH**)
Understanding and optimizing solution-processed systems

October 2
Alex Bronstein (**Technion – Israel Institute of Technology**)
Learning to see in the Data Age

October 4
Manfred Einsiedler (**ETH Zürich**)
Mathematics Colloquium
Disjointness in Ergodic and Number Theory

October 5
Sten Grillner (**Karolinska Institute**)
The brain in action: evolutionarily conserved control strategies

October 23
Gijsje Koenderink (**TU Delft**)
The cell as a material

November 6
Mark Tuckerman (**New York University**)
Topology, molecular simulation, and machine learning as routes to exploring structure, dynamics, and phase behavior in atomic and molecular crystals

November 8
Nigel Hitchin (**University of Oxford**)
Mathematics Colloquium
Spinors and vector bundles on algebraic curves

November 13
Claudia Pasquero (**Università degli Studi di Milano-Bicocca**)
Effects of land-sea distribution on the mid latitude climatic response to anthropogenic forcing

December 6
Sarah Zerbes (**ETH Zürich**)
Mathematics Colloquium
Euler systems and the Birch—Swinnerton-Dyer conjecture

December 18
Jack Harris (**Yale University**)
Measuring the knots & braids of non-Hermitian oscillators

Technology Transfer Talks

September 19
Alessandro Venturino (**Syntropic Medical**)
The New Standard In Drug-Free Mental Health Therapy

October 17
bigX 23
bigX 23 ISTA Innovation Exchange: eXcite, eXplore, eXpand

Boards & Donors

Board of Trustees

The Board of Trustees oversees the development of the Institute, while acting as its highest authority and ensuring that it adheres to its founding principles and vision. It provides guidance to the management and—among other tasks—is responsible for approving the statutes of the organization and its strategic direction; the budget and annual financial statements; the appointment of the President, the Scientific Board, and the Managing Director; and the procedures for academic appointments and the promotion of scientists.

The Board of Trustees consists of 15 members. Nine of them are internationally well-known scientists, four are appointed by the Federal Government, and three are appointed by the Government of Lower Austria. In July 2023, Elisabeth Engelbrechtsmüller-Strauβ took over from Claus J. Raidl as chair of the Board of Trustees.

Chair (from July 1, 2023):
Elisabeth Engelbrechtsmüller-Strauβ, CEO/CFO, Fronius International GmbH, Pettenbach, Austria

Chair (until June 30, 2023):
Claus J. Raidl, Former President, Oesterreichische Nationalbank, Vienna, Austria

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The Executive Committee is a subcommittee of the Board of Trustees and has, among others, the following rights and duties:

- ↗ Act on behalf of the Board of Trustees in all matters between the meetings of the Board of Trustees.
- ↗ Hold preliminary discussions on matters to be brought for approval to the Board of Trustees, such as the annual budget.

Chair:
Iain Mattaj

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(until June 30, 2023)

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Scientific Board

The Scientific Board prepares recommendations for the scientific direction of the Institute. It provides guidance to ensure a high degree of scientific productivity, and among other duties, it organizes internal evaluations of the various research fields.

The Scientific Board consists of at least ten researchers who are recognized internationally at the highest levels and an additional (non-voting) member with outstanding management experience.

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Peter Fratzl, Director, Max Planck Institute of Colloids and Interfaces, Potsdam, Germany

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Bradley Nelson, Professor, Institute of Robotics and Intelligent Systems, ETH Zurich, Switzerland

Helen Saibil, Professor, Department of Biological Sciences, Birkbeck College, London, United Kingdom

Non-voting Member:
Claus J. Raidl, Former President, Oesterreichische Nationalbank, Vienna, Austria

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Krzysztof Pietrzak, Information and System Sciences Area Chair

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Just a short bus ride from the capital city of Vienna and surrounded by nature, the campus in Klosterneuburg offers a sense of peace and calm, balancing the heady buzz of scientific activity emanating from every building on campus.

6 Sports Facilities

77,200 m²

Usable Building Space in 2023

ISTA

Imprint

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Classic Smooth 300 g/m²

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