

## Foreword



Self-organization can be observed at multiple scales in biology, from protein folding and aggregation to organ shape acquisition to collective movements of animals. Quantitative biology has made key advances that shed light on these phenomena, and out-of-equilibrium physics provides a natural—and constantly expanding—framework in which to think about these problems in a different way. However, a generic integration of the two areas, which is the general focus of my research, is largely still lacking.

After studying physics and chemistry, I did my PhD in theoretical biophysics, researching tissue mechanics at the Institut Curie in Paris. Following my doctoral studies, I moved to the University of Cambridge in 2014 to work as a postdoc on statistical physics models of stem cell fates. Throughout my scientific career, I have had the chance to get in closer and closer contact with developmental and stem biologists.

When first visiting IST Austria for interviews, I was of course struck by the diversity and excellence of the research, but also by how dynamic and enthusiastic everyone was about achieving the very ambitious objectives of the Institute. Since my arrival at IST Austria in September 2017, I have very much enjoyed the size of the campus community: compact enough to foster interdisciplinarity and close contact between fields, but large enough to reach a critical mass in several areas. Little wonder that I am extremely glad to be part of this adventure.

Edouard Hannezo | Assistant Professor, IST Austria



### Ryuichi Shigemoto becomes member of Academia Europaea

IST Austria Professor Ryuichi Shigemoto has been named member of Academia Europaea (section: physiology and neuroscience). The neuroscientist investigates the molecular basis of neuronal transmission mediated by neurotransmitter receptors or ion channels. More specifically, Shigemoto and his research group study the left-right asymmetry of the brain. This so-called laterality has been known for a long time, but the molecular determinants are not yet well understood.

IST Austria President Thomas Henzinger is delighted: “My congratulations to Professor Ryuichi Shigemoto on being elected to the Academia Europaea. Such a membership is a great honor and a tribute to his excellent accomplishments in neuroscience.” In addition to Ryuichi Shigemoto, four IST Austria professors are members of the Academia Europaea: computer scientist Thomas Henzinger, neuroscientist Peter Jonas, and the mathematicians Herbert Edelsbrunner and László Erdős.



### Two ERC Starting Grants for IST Austria Professors

IST Austria Professors Johannes Fink and Maximilian Jösch have been awarded Starting Grants by the European Research Council (ERC). With the two new awardees, 31 professors at IST Austria have so far been awarded highly prestigious research grants by the ERC.

Experimental physicist Fink will develop a transceiver for fiber optic quantum networks. By integrating silicon photonics and superconducting circuits, he seeks to achieve a low-loss and high-bandwidth transceiver and extend the range of current fiber optic quantum networks.

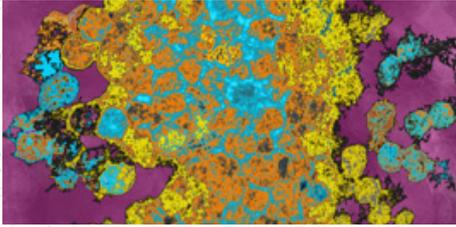
Neuroscientist Jösch will investigate the neuronal mechanisms required for attention. His studies will allow for the characterization of the neuronal mechanisms of attentional and goal directed behaviors, as well as for the understanding of the brain-wide modulations that change these computations according to the momentary need of the animal.



### Mikhail Lemeshko wins Ludwig Boltzmann Prize

IST Austria Professor Mikhail Lemeshko is this year's sole winner of the Ludwig Boltzmann Prize. Established in 1953, the prize is awarded once every two years to honor outstanding results achieved by a young researcher in theoretical physics. In his award-winning paper, he demonstrated that angulons can simplify the theoretical description of molecules in a solvent and moreover explain experimental data that has been collected over the last 20 years. The prize was awarded to him on August 22, 2017, at the joint annual meeting of the Swiss and Austrian Physical Societies in Geneva.

Mikhail Lemeshko obtained his PhD from the Fritz Haber Institute of the Max Planck Society and performed postdoctoral research at Harvard University before joining IST Austria in 2014. “It is a great honor for me,” says the physicist, “one that was made possible by the inspiring and supporting atmosphere created for junior physics faculty at IST Austria.”



## Cell contacts in embryonic development determine cellular fate

The average human consists of about 37.2 trillion cells. But not all cells are created equal: while muscle cells contain the molecular machinery to contract and relax your muscles, some neurons send meter-long axons from the spinal cord to the tip of your toes, and red blood cells bind oxygen and transport it around the body. How does a cell

“know” which function to fulfill? In a *Developmental Cell* paper, the group of Carl-Philipp Heisenberg, including first author Vanessa Barone, sheds light on how a cell’s fate is determined.

In the human body, cells do not just sit next to each other. Instead, neighboring cells can form contacts with each other: connections of different size, strength and duration that reach from one cell to another. The Heisenberg group used zebrafish to investigate whether signaling between cells and cell-cell contact formation affect each other, and if they influence how a cell’s fate is determined.

The researchers looked at progenitor cells within the forming anterior axial mesendoderm that give rise to either the head mesoderm or endoderm of

the developing embryo. The authors identified a positive feedback loop between cell-cell contact formation and cell fate specification in this system: these processes promote each other in that contact formation triggers high nodal/TGFβ-mediated cell-cell signaling, which is required for head mesoderm cell fate specification and differentiation. In turn, nodal signaling promotes cell-cell contact formation. The authors further observed that when mesendoderm progenitor cells form long-lasting cell-cell contacts, the cells become head mesoderm, whereas if they only form short-lasting contacts, they form endoderm. Thus, the authors were able to identify cell-cell contact duration as a key feature in controlling the level of cell-cell signaling, which then determines binary cell fate decisions during embryonic development.



## Strange undertakings: ant queens bury dead to prevent disease

Ant queens may bury other queens to avoid infection when co-founding a new colony. A *BMC Evolutionary Biology* study by Christopher Pull and Sylvia Cremer demonstrated that in cases where two ant-queens founded a colony together and one of the queens died before the first workers arrived, the surviving queen performed “undertaking behavi-

ors”—behaviors directed at dead individuals, such as biting and burying the corpse—possibly to prevent pathogen transmission. The authors found that biting and burial were associated with a seven-fold reduction in the odds of a queen dying.

Corresponding author Christopher Pull states: “Ant queens usually focus on reproduction and do not engage in any risky or dangerous tasks. That’s why we were surprised to find that while ant queens do not avoid founding new colonies with other sick queens, they perform undertaking behaviors that may have an impact on their survival. We found that queens that perform these behaviors are actually less likely to contract infections from dead co-founders and are less likely to die compared to those that do not perform undertaking.”

Investigating the behavior of queens of the black garden ant—18% of which co-found colonies, usually in pairs—the authors found that if two queens shared a closed nest with only one chamber and one of them died, 74% of surviving queens would bite the dead queen to dismantle it and 67% would then bury the pieces. If two co-founding queens shared an open nest with more than one chamber, 78% of surviving queens would remove the dead queen from the nesting chamber, while most of the remaining 22% of queens would bite and bury the corpse.

The researchers found that while biting and burial was associated with increased chances of survival, the removal of a dead queen from the nest had no statistically significant effect on mortality.



## No gene is an island

Genes do not exist in isolation. Like beads on a string, they sit next to each other on long DNA molecules called chromosomes. For a long time, little was known about how the position of a gene on a chromosome affects its evolution. A study by IST Austria Professor Călin Guet and PhD student Magdalena Steinrück shows that a gene’s neighborhood can influence whether and how the activity of a

gene changes. Their study was published in the open access journal *eLife*.

From bacteria to humans, the way organisms look and function depends a lot on how much product is made from each gene. The activity of a gene can be changed by mutations, alterations in the DNA that can be inherited. This can make the organism better adapted to its environment—or worse. For example, a bacterium that produces more of a protein that helps it get rid of an antibiotic may survive, while its competitors are killed by the antibiotic. In their study, Steinrück and Guet used experimental evolution to investigate how the position of a gene on the chromosome influences mutations that increase the activity of the gene.

The researchers engineered the DNA of the gut bacterium *Escherichia coli* to place an antibiotic resistance gene at different positions of its chromosome. This gene allows the bacterium to pump the antibiotic tetracycline out of the cell. At the start of the experiment, the gene was almost completely switched off. The researchers then added tetracycline to the bacteria’s environment. This challenges the bacteria to switch the gene on via mutation, as producing more of the antibiotic resistance gene allows them to pump the antibiotic out, so that they multiply and survive. The bacteria were much more likely to survive with the resistance gene in certain places of the chromosome than at others. Thus, the gene’s neighborhood affects which types of mutations can occur—some forms of mutations can only occur if the neighboring genes permit them to.

## FENS-Kavli Network of Excellence symposium

The FENS-Kavli Network of Excellence (FKNE) Winter Symposium will take place at IST Austria on December 3-5, 2017. Supported generously by the Kavli Foundation, the Federation of European Neuroscience Societies (FENS) established a multidisciplinary network of excellent early to mid-career European neuroscientists in 2014 to promote scientific exchange. The 2017 FKNE Winter Symposium will serve as a forum for scientific discussion and an opportunity to boost collaborations within and outside of the network. In order to foster a lively scientific debate, the program will include round table discussions on the topics presented during the meeting.

For information and registration visit the [symposium website](#).



## Frontiers of Circuit QED and Optomechanics

## Frontiers of Circuit QED and Optomechanics conference

An international conference on Frontiers of Circuit QED and Optomechanics (FCQO) will be held at IST Austria on February 12-14, 2018. Organized by IST Austria and chaired by Dr. Shabir Barzanjeh and Prof. Johannes Fink from the Quantum Integrated Devices lab, the FCQO 2018 meeting has been designed to attract and engage the best researchers in the fields of quantum opto- and electro-mechanics, circuit quantum electrodynamics, and optical to microwave quantum transduction. As an interactive platform for the exchange of new ideas, the conference will bring together world-renowned leaders in the fields and a number of top young researchers to present both theoretical and experimental aspects of the field, with a strong emphasis on the most cutting-edge experimental progress.

For information and registration visit the [conference website](#).

## COLLOQUIUM SPEAKERS

**PAST SPEAKERS:** Robert Tarjan, Princeton University (Oct 2) | Christine Jacobs-Wagner, Yale University (Oct 9) | Vinod Vaikuntanathan, Massachusetts Institute of Technology (Oct 16) | Tobias Walther, Harvard University (Oct 23)

**FUTURE SPEAKERS:** Kenneth Birnbaum, New York University (Nov 13) | David Schneider, Stanford University (Nov 29) | Marcos Gonzalez-Gaitan, University of Geneva (Nov 27) | Jean-Michel Raimond, Kastler Brossel Laboratory (Dec 4) | Cosma Shalizi, Carnegie Mellon University (Dec 18) | Kathryn Hess, École polytechnique fédérale de Lausanne (Jan 8) | Adam Summers, University of Washington (Jan 15) | Mark Pauly, École polytechnique fédérale de Lausanne (Jan 29)

## SELECTED RECENT PUBLICATIONS

Barton, Nicholas H, Etheridge, Alison M, Veneer, Amandine: The infinitesimal model. In: *Theoretical Population Biology*. Academic Press, 2017, 1-54.

Barzanjeh, Shabir, Wulf, Matthias, Peruzzo, Matilda, Kalaei, Mahmoud, Dieterle, Paul B, Painter, Oskar, Fink, Johannes: Mechanical on chip microwave circulator. In: *Nature Communications*. Nature Publishing Group, 1, 2017, Article number: 953.

Bighin, Giacomo, Lemesko, Mikhail: Diagrammatic approach to orbital quantum impurities interacting with a many-particle environment. In: *Physical Review B - Condensed Matter and Materials Physics*. American Physical Society, 8, 2017, Article number: 085410.

Heiss, Teresa, Wagner, Hubert: Streaming algorithm for Euler characteristic curves of multidimensional

images. In: *CAIP: Computer Analysis of Images and Patterns (LNCS)*. Springer, 2017, Epub ahead of print.

De Martino, Daniele, Capuani, Fabrizio, De Martino, Andrea: Quantifying the entropic cost of cellular growth control. In: *Physical Review E Statistical Nonlinear and Soft Matter Physics*. American Institute of Physics, 1, 2017, Article Number: 010401.

Novak, Sebastian, Barton, Nicholas H: When does frequency-independent selection maintain genetic variation?. In: *Genetics*. Genetics Society of America, 2, 2017, 653-668.

Royer, Amélie, Kolesnikov, Alexander, Lampert, Christoph H: Probabilistic Image Colorization. In: *BMVC: British Machine Vision Conference*. BMVA Press, 2017.

Schmalhorst, Philipp S, Deluweit, Felix, Scherrers, Roger, Heisenberg, Carl-Philipp, Sikora, Mateusz: Overcoming the limitations of the MARTINI force field

in simulations of polysaccharides. In: *Journal of Chemical Theory and Computation*. American Chemical Society, 10, 2017, 5039-5053.

Serbyn, Maksym, Zlatko, Papić, Abanin, Dmitry: Thouless energy and multifractality across the many-body localization transition. In: *Physical Review B - Condensed Matter and Materials Physics*. American Physical Society, 2017, Article number: 104201.

Vukušić, Lada, Kukučka, Josip, Watzinger, Hannes, Katsaros, Georgios: Fast hole tunneling times in germanium hut wires probed by single-shot reflectometry. In: *Nano Letters*. American Chemical Society, 9, 2017, 5706-5710.

A full list of publications from IST Austria can be found at [publist.ist.ac.at](http://publist.ist.ac.at).