#### Public Understanding of Life Sciences / Chemical Ecology



Max Planck Institute for Chemical Ecology

Newsletter November 2018



### Leaf molecules as markers for mycorrhiza

Mycorrhizal fungi facilitate plants' nutrient uptake and help them thrive under extreme conditions. Blumenol C derivates, metabolites found in above-ground parts of plants, reveal plants' successful association with mycorrhizal fungi ... **p. 3** 



### How beetle larvae thrive on carrion

Burying beetles rely on their gut symbionts in order to transform decaying carcasses into nutritious nurseries for their young. Beetles are able to replace harmful microorganisms with their own beneficial gut symbionts, turning a carcass into a nursery with a microbial community that promotes larval growth ... p. 4



### Sex or food? Diatoms can make decisions

Diatoms show complex behavior: They can decide to search for sex partners or for nutrient sources, depending on the degree of their starvation and the urgency of the need to mate ... **p. 5** 





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### Focus on the microverse



Happy faces at a spontaneous celebration on September 27 in the senate hall of Jena University after funding of the microverse cluster was confirmed. Among the celebrators were lan Baldwin (5th from left) and Max Planck Fellow Georg Pohnert (6th from left).



Spokesperson of the microverse cluster, Axel Brakhage, participated via Skype. He was in Bonn, where the German Council of Science and Humanities and the German Research Foundation announced their decision in a press conference.

Photos: Jan-Peter Kasper, FSU

Soil fungi as mutualistic partners of plants, gut symbionts of carrion beetles and diatoms, which are important components of marine phytoplankton, are the focus of the research highlights in this issue of PULS/CE. This focus fits with the recent success... of the Jena research cluster "Balance of the Microverse," which was selected for funding on September 27, 2018, in the framework of the Excellence Initiative of the German Council of Science and Humanities.

Ian Baldwin, director of the Department of Molecular Ecology at our institute, member of the executive board and principal investigator in the cluster, explains why it is important to take a close look at microorganisms when studying ecological interactions:

"The plants and animals that we study at the institute, are but Trojan horses for large populations of microorganisms that inhabit the internal spaces of our study organisms. The numbers of cells in these internal microbiomes can frequently be larger than the number of cells of the hosts. Researchers are realizing that these microbiomes can have very important functional consequences for hosts, influencing their fitness and even the outcomes of interactions among different hosts. So it is important to recognize that in what appears to be binary interactions between plants and insects are more frequently much richer and more complicated, given the important roles played by the large numbers of microorganisms involved."

The new cluster of excellence is a great success for Jena as a research location. Beginning in January 2019, the research network between Friedrich Schiller University and several non-university institutes which are also located in Jena will be funded for seven years with up to 50 million euros. These are wonderful prospects, also for our institute. Baldwin emphasizes:

"With the funding of the Microverse Cluster of Excellence, we will be able to extend our plantherbivore research focus into these microbiomes for both plants and herbivores, and focus on how these microbiomes are recruited and maintained in balanced associations with their hosts. More importantly the Micoverse will attract new expertise and consolidate existing research expertise in the Jena research landscape to foster the ability to characterize and manipulate these ubiquitous microscopic players in ecological interactions."

We are very excited about the possible new research collaborations that may be facilitated by this cluster of excellence. [A0]

https://www.microverse-cluster.de





Max Planck Institute for Chemical Ecology

## Leaf molecules as markers for mycorrhizae

The relationship between plants and so-called arbuscular mycorrhizal fungi is considered one of the most important factors for the evolution of terrestrial plants. The mutualistic association allows the plant to better absorb nutrients, such as phosphate. Moreover, the symbiosis makes plants more tolerant of insect attack, pathogens and drought.

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Scientists from the Department of Molecular Ecology discovered that certain leaf metabolites can be used as markers for functional mycorrhizal associations. They found that blumenol C derivates accumulate in the leaves when arbuscular mycorrhizal fungi successfully colonize plant roots. The researchers were able to show blumenol accumulation in the leaf tissues of other plant species, including important crop varieties and vegetables, after these plants had established successful symbiotic relationships with mycorrhizal fungi. The ubiquity of markers in shoots across distant plant families is likely due to the long common history of mycorrhizal fungi and plants.





Regardless of the function of these substances, the approach provides a robust and easy-to-apply tool which has the potential to fundamentally change the future of mycorrhizal research and plant breeding. Both breeding programs, which rely on high-throughput screenings, as well as basic research into fundamental questions about the information transferred from plant-to-plant through fungal networks, could benefit from these findings. Phosphate is a major component of fertilizers and therefore indispensable for agriculture and food production. However, phosphate deposits are limited and often located in areas of conflict. Experts are already talking about a pending shortage of phosphate which could lead to a global food crisis.

The new screening method could help breed plants that are more able to negotiate favorable relationships with mycorrhizal fungi so as to acquire phosphate more efficiently. [AO/KG] Detection of symbiotic mycorrhyzal fungi on the roots via WGA staining. *Image: Ming Wang, MPI-CE* 

Left below: Tobacco plants produce blumenol C derivates (blue) in their roots when they have established an association with mycorrhizae (pink). The substances can be used as foliar markers for the symbiosis. *Graphic: Ming Wang, MPI-CE* 

Original Publication: Wang, M., Schäfer, M. Li, D., Halitschke, R., Dong, C., McGale, E., Paetz, C., Song, Y, Li, S., Dong, J., Heiling, S., Groten, K., Franken, P., Bitterlich, M., Harrison, M., Paszkowski, U., Baldwin, I. T. (2018). Blumenols as shoot markers for root symbiosis with arbuscular mycorrhizal fungi, eLife 2018;7:e37093





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### How beetle larvae thrive on carrion



Above: Fluorescence *in situ* hybridization (FISH) is used to visualize the abundance of microbes in the hindgut of the burying beetle *Nicrophorus vespilloides*. This technique uses different probes to detect and localize general bacteria (green), specific gut symbionts (yellow-orange) and the host cell nuclei (purple). *Image: Martin Kaltenpoth, JGU Mainz* 

Right: A burying beetle caring for its offspring. The carcass of a small rodent serves as a nursery after it has been preserved with anal secretions from the beetle's gut containing symbiotic microorganisms. The symbionts make sure that the larvae thrive. Photo: Shantanu Shukla, MPI-CE The nutrient-rich resources for breeding exploited by burying beetles are unexpected: Their larvae feed on the dead bodies of small animals. If untended by these beetles, carcasses are usually taken over by microbial decomposers. Scientists from the Department of Entomology and their partners have found out that the burying beetle *Nicrophorus vespilloides* preserves the food source for its offspring by inoculating it with beneficial microbes from its own gut.

Beetles make use of the carcasses not by suppressing microbes but by replacing the native microbial community with their own gut microbes. Tended carcasses showed suppression of a soil-associated mold; instead, the growth of a beetle-associated yeast can be observed. The researchers also tested the effect of the carrion microbiota on host fitness by measuring larval performance with and without the microbial symbionts present on the carrion. The negative effects on larval growth were considerable: Larvae that fed on carcasses from which the matrix had been removed were significantly smaller although they had consumed the same amount of tissue. The study shows how insects can modify their habitats by culturing symbionts both in their guts as well as externally on a breeding resource in order to increase fitness. The burying beetle is a fascinating example of symbiont-enabled exploitation of challenging resources.

This study was funded the Max Planck Society and the Fraunhofer-Gesellschaft via the collaborative project "AIM-Biotech – Application of Insect-associated Microbes in industrial Biotechnology". [A0]



Original Publication: Shukla, S. P., Plata, C., Reichelt, M., Steiger, S., Heckel. D. G., Kaltenpoth, M., Vilcinskas, A., Vogel, H. (2018). Microbiome-assisted carrion preservation aids larval development in a burying beetle. **PNAS**, DOI: 10.1073/pnas.1812808115







Max Planck Institute for Chemical Ecology

# Sex or food? Diatoms can make decisions

Diatoms dominate marine phytoplankton, which is ubiguitous in our oceans. On shores and beaches, these algae can be observed as biofilms on rocks and other surfaces. The food source for many marine animals, diatoms are also responsible for an important ecosystem service: They contribute to global photosynthesis and thus to the production of oxygen on our planet. Moreover, they are being discussed as possible producers of biofuels. Together with partners in Belgium, researchers from Jena University and the Max Planck Fellow Group have found that these unicellular microorganisms demonstrate complex behavior: They choose between searching for sex partners and searching for nutrient sources, and can adapt their behavior to different external stimuli based on an evaluation of their own needs. Although the algae depend on nutrients in order to reproduce, they also need sexual partners, which they find by following pheromone traces. In experiments, Seminavis robusta diatoms directed their orientation towards either nutrient sources or possible partners, depending on the degree to which they had been starved and the need to mate. Seminavis robusta is an ideal model organism for behavioral studies in the lab: Its cells respond to different environmental conditions and their sexual behavior can be controlled.



Diatom cells aggregate around a silicate-loaded bead. Image: Karen Grace Bondoc, FSU Jena



The scientists cultivated cells under changing conditions, confronting the cells with different amounts of nutrients and with sex pheromones. Since diatoms primarily reproduce asexually by cell division, sexual reproduction becomes necessary for their survival, because, after continuous division, the cells may fall below a minimum size and die. Diatoms also search actively for nutrients they need to form their cell walls, tracing silicate minerals in their environment and moving towards this food source. The study shows that diatoms adapt their behavior to environmental changes, and move towards pheromones or food sources depending on how much they were interested in sex or in nutrients. Until now, this kind of decision-making has been attributed only to higher organisms. The decision of one diatom does not only determine the fate of a single cell. Moreover, it is crucial for the dynamics of biofilms, which are composed of communities of countless diatoms. [AO/KG]

Georg Pohnert is studying algal cultures in his lab. He is the chair of Instrumental Analytics at Friedrich Schiller University, in Jena. In 2015, he was appointed Max Planck Fellow by the Max Planck Society and has headed the Max Planck Fellow Group on Interactions in Plankton Communities since then. *Photo: Jan-Peter-Kasper, FSU* 

Original Publication: Bondoc, K. G. V., Lembke, C., Lang, S. N., Germerodt, S., Schuster, S., Vyverman, W., Pohnert, G. (2018). Decision-making of the benthic diatom Seminavis robusta searching for inorganic nutrients and pheromones. The ISME Journal. DOI 10.1038/s41396-018-0299-2









*Tupiocoris notatus* is a widespread tobacco pest. The sap-sucking bug has piercing mouth parts and feeds on the cell contents of leaves. *Photo: Christoph Brütting, MPI-CE* 



A larva of the Western corn rootworm Diabrotica virgifera is attacking the root of a maize plant. Photo: Cyril Hertz

# Sap-sucking bugs manipulate their host plants' metabolism for their own benefit

Researchers from the Department of Molecular Ecology have shown for the first time that freeliving sap-sucking *Tupiocoris notatus* bugs can manipulate the metabolism of their host plants (*Nicotiana attenuata*) in order to create stable, nutritious feeding sites. They do so by copying plant hormones and injecting these into the hosts' leaves. The bugs use a feeding strategy similar to that used by endophytic insect species, which live inside plants. The discovery could aid in the development of effective pest management strategies. [KG/A0]

**Original Publication:** Brütting, C., Crava, C. M., Schäfer, M., Schuman, M. C., Baldwin, I.T. (2018). Cytokinin transfer by a free-living mirid to Nicotiana attenuata recapitulates a strategy of endophytic insects **eLife** 2018;7:e36268

#### How the corn rootworm hijacks the nutrient uptake strategy of its host plant

Secondary metabolites released by maize into the soil bind to iron and facilitate its uptake by the plant. The Western corn rootworm (*Diabrotica virgifera*), the most devastating maize pest, is attracted by these iron complexes, extracts the bound iron from the plant and uses it for its own nutrition. With this study, researchers from the University of Bern and the Department of Biochemistry offer a new explanation for the extraordinary success of this global pest. [ME]

Original Publication: Hu, L., Mateo, P., Ye, M., Zhang, X., Berset, J. D., Handrick, V., Radisch, D., Grabe, V., Köllner, T. G., Gershenzon, J., Robert, C. A. M., Erb, M. (2018) Plant Iron Acquisition Strategy Exploited by an Insect Herbivore. **Science**, 361 (6403), 694-697



Desert ants process food and nest odors differently in their brains. *Photo: Markus Knaden, MPI-CE* 

#### Desert ants have an amazing memory for food odors

Scientists from the Department of Evolutionary Neuroethology used behavioral experiments in the Tunisian desert to show that *Cataglyphis fortis* ants are able to learn many food odors quickly and remember these for the rest of their lives. However, their memory for nest odors seems to differ: Whereas food odors are learned and retained after a single encounter, ants need several trials to memorize nest odors. Moreover, ants quickly forget a nest-associated odor after it has been removed from the nest. In ants, odors are obviously processed differently in the brain depending on whether they are food or nest cues. [AO/KG]

**Original Publication:** Huber, R., Knaden, M. (2018). Desert ants possess distinct memories for food and nest odors. **PNAS**, 115 (41) 10470-10474



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Max Planck Institute for Chemical Ecology

# Max Planck Day in Jena

September 14, 2018, was a memorable day: Under the motto "Wonach suchst du - Forschen ist Neugier" (What are you looking for –

Research is curiosity), 82 Max Planck Institutes in 35 different cities put together a diverse program for the public. The logo and heart of the event was a colorful hashtag with images representing science in the Max Planck Society. The Jena Max Planck Institutes for Biogeochemistry, Chemical Ecology and the Science of Human History came up with

something special for this occasion: Co-workers from all three institutes and their friends put on a flashmob, dancing to Latin American music. After their exuberant performance, they distributed #wonachsuchstdu postcards with research questions to people in the crowd

> who had stopped by to watch. The flashmob successfully started things off, and during the evening all lovers of quiz shows and puzzles were invited to a pub quiz at Paradiescafé. Teams were asked questions from six areas: the Max Planck Society, physicist and Nobel Prize winner Max Planck, Jena, and research in the three Jena MPIs. 25 teams and a total of

more than 120 participants filled the hall in the café to capacity for an entertaining and exciting evening. [AO/KG]



Dancers after the flashmob. Taking DJ Deorro's "Bailar" (dance) literally, they offered a lively performance (large photo below).



Puzzled looks during the pub quiz.



Teresa Sporer, Florencia Campetella, Matilda Gikonyo, Zhi-Ling Yang, Lin-Ling Ren and Franziska Beran (from left to right; here with Bill Hansson) represented the MPI-CE at the Science Marketplace in Munich.

Photos: Hans-Georg Sell, MPI-SHH, (Hashtag), Eberhard Fritz, MPI-BGC (Flashmob), Susanne Hejja, MPI-BGC (Flashmob and Pub Quiz), Franziska Beran, MPI-CE (Science Market Place Munich)





https://wonachsuchstdu.mpg.de/



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Since November 1, 2018, chemist Sarah O'Connor has been a new director at our institute. At first, she will work from the UK. She plans to move to Jena in June 2019 to work at the institute full-time and to set up her new department. With her as a director, our institute will continue to have a chemical focus. *Photo: Thuy Dang* 

#### Sarah O'Connor, new director at the institute

Sarah O'Connor, a biological chemist at the John Innes Centre in Norwich, United Kingdom, has been appointed new director at the Max Planck Institute for Chemical Ecology. Replacing Wilhelm Boland, Sarah O'Connor will continue to focus on chemistry in her new department. The natural product researcher, who was born in the United States, studies the dazzling array of plant metabolites which are often of medical interest. She is especially interested in exploring how plants construct complex compounds from simple building blocks and how the metabolic pathways have evolved in the course of evolution.

Focusing her research on plant alkaloids and iridoids, Sarah O'Connor studies plants in the Lamiaceae family, as well as the Madagascar periwinkle (*Catharanthus roseus*) and Indian snakeroot (*Rauvolfia serpentina*). Fundamental knowledge of plant metabolic pathways shall help to better use the abundance of compounds and biocatalysts which can be found in the plant kingdom, and even produce "novel compounds" with better properties, such as reduced side effects.

Sarah O'Connor received her Ph.D. for her work on protein glycosylation in Barbara Imperiali's lab at the Massachusetts Institute of Technology (MIT). She was a postdoc at Harvard Medical School and returned to MIT as a professor from 2003 to 2010. Since 2011, she has been a project leader in the Department of Biological Chemistry at the John Innes Centre in Norwich. Awards for her outstanding research include the Alfred P. Sloan Research Fellowship, the Pfizer Award of the American Chemical Society, the Wolfson Research Merit Award of the Royal Society, and the Wain Medal. In 2017, she was elected member of the European Molecular Biology Organization (EMBO). In 2018, she was awarded a large EU project (Advanced ERC Grant) to investigate biochemical pathways in medicinal plants.

David Heckel is looking forward to this excellent scientist joining our institute: "The other directors and I are delighted to have a new colleague, who will be very important in shaping the research direction of our Institute." [KG/A0]

VII. Kunstausstellung 23.10.2018 bis 21.12.2018 Vielfalt in Linie und Farbe



#### 7th Art Exhibition with Works by Marina Hauck

From October 23 until December 21, 2018, works by artist Marina Hauck will be shown in the foyer of the institute. The motto of the exhibition is "**Vielfalt in Linie und Farbe**" (**A Diversity of Line and Color**). A broad selection of topics and techniques will be shown: works on paper and canvas, applied with chalk, ink, fineliner, color and graphite pencils. The artist also offers impressions of our environment using watercolor, acryl and oil paints, portraying aspects in our everyday life. The exhibition will be open to the public from Monday to Friday between 9:00 a.m. and 4:00 p.m. Entrance is free.

http://www.ice.mpg.de/ext/index.php?id=hauck2018



#### www.ice.mpg.de

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