One simple molecule regulates mating
A relatively simple molecule, a fatty acid methyl ester called methyl laurate, is able to regulate complex sexual behavior in *Drosophila*. This pheromone triggers courtship behavior in males and is responsible for mating success … p. 3

Feeding caterpillars make leaves shine
Scientists visualize calcium signals in plants which are elicited by wounding and ultimately regulate defense responses to herbivores. Using a highly sensitive camera system, the researchers were able to track calcium flow in the plants … p. 4

Deceptive flowers
Tobacco plants use their flowers’ scent and nectar to manipulate pollinators and herbivores. Natural variations of scent biosynthesis and nectar secretion in wild tobacco populations ensure that reproductive success is optimized while simultaneously herbivores are kept at bay … p. 5
How integration can succeed

An international MPI-CE football team participated in a benefit tournament on September 25, 2015. As a part of an intercultural week, the goal of this event was to promote exchange between refugees accommodated in Jena and the citizens of Jena. With the participation of our team, we wanted to signal that we support internationality and openness, especially during a time of global refugee crisis. The participants: Tobias Becker, Ran Li, Roman Huber, Jan Günther, the children Merlin and Jacob, Shuqing Xu and Guillermo Jiménez Alemán (in the back), Jens Preßler and Vinzenz Handrick (in the front). Photo: Angela Overmeyer

Dear readers!

The question of how people from different countries, cultures and religions can live together is being discussed publicly in German society today more than ever in light of the challenge of taking care of thousands of refugees who have fled areas of crisis and war and come to our country hoping for a life in peace.

At our institute, internationality is something we take for granted. Science is global, researchers study topics that may change the future of all humans. About half of our scientists come from abroad. There are numerous collaborations with international partners on all continents. In a recent survey, our international co-workers were asked if they felt welcome at our institute and in our town, what they need and what they think contributes to successful integration.

Their positive feedback should make us all very happy. This includes, for example, language. The fact that the institute language is English and that all information is provided in German and English means that nobody is left out. Yet international co-workers are thankful for the opportunity to attend free German classes at the institute. Learning German helps them cope with everyday situations and to communicate with locals. Some research groups even appoint an experienced member to take care of the newcomer: He or she is available for answering all sorts of questions and can thus provide the support needed to familiarize new people with Jena’s geography, regulations, local culture, etc. When eating together, organizing joint activities or parties, we feel part of the whole institute, whether we are German or from abroad.

Of course, our institute is only a tiny part of the whole society. We have the advantage that we all speak the same language, the language of science, that we have a common goal, to gain new insights in the field of chemical ecology. However, what is successful on a small scale can also function on a larger scale provided that we take care for others, try to understand each other, offer help and support and discover common interests.

Angela Overmeyer
One simple molecule regulates mating

Pheromones are signal molecules that pass information from individuals of one species to their conspecifics. In addition to aggregation pheromones, which prompt insects of the same species to come together, or alarm pheromones, which warn conspecifics about imminent danger, there are sex pheromones, and these are quite well-known. The sexual attractant used by female silkworm moths, bombykol, was the first of many pheromones to be identified, and its effect on males was proven in the late 1950s. Yet the female sex pheromone – the signal molecule which attracts males and triggers mating behavior – of the vinegar fly *Drosophila melanogaster* remained until recently unidentified.

Researchers from the Department of Evolutionary Neuroethology now identified methyl laurate as the *Drosophila melanogaster* sex pheromone. Physiological and genetic data indicated that the flies must have a neuron type that responded to a specific, yet unidentified, compound within odor collections from flies. When this neuron type, which expresses the specific olfactory receptor Or47b, was missing, mating behavior in males was inhibited. Therefore, Hany Dweck, who studied *Drosophila neuroecology*, began collecting odors from thousands of vinegar flies. In order to analyze single odor components, he used a new technique known as Thermal Desorption GC-MS. This combination of gas chromatography (GC) and mass spectrometry (MS) also uses thermal desorption, which helps to measure and identify even the tiniest amounts of volatile substances. He then performed electrophysiological measurements to test all identified compounds for their ability to activate the pheromone-specific neuron.

From all tested volatile compounds that vinegar flies emit, only one substance triggered a strong response in this neuron: methyl laurate, a substance with a relatively plain molecule structure. The compound is detected by a neuron which expresses the olfactory receptor Or47b, a receptor that responds exclusively to methyl laurate. In males, methyl laurate triggers courtship behavior. Methyl laurate is also detected by another sensory neuron type that expresses the olfactory receptor Or88a. Flies which lack the olfactory receptor Or47b are still attracted by the odor of other flies; however, their mating behavior is considerably reduced. Flies which lack the olfactory receptor Or88a are no longer attracted to fly-specific odors; however, their mating behavior is uninhibited. The novel pheromone activates two different circuits: one is involved in courtship and mating of males and females, the other one in aggregation.

In further experiments, the scientists want to find out whether the fly produces the substance by itself or whether symbiotic bacteria may be involved. [AO]
Calcium is a universal intracellular messenger. In plants, many physiological processes are mediated by calcium ions, especially responses to abiotic and biotic stresses, such as feeding caterpillars. These trigger the activation of a number of defense mechanisms. If a leaf is attacked by an insect, the wound signal which emanates from the affected leaf is transmitted to other, unattacked leaves.

In order to visualize this signal, scientists from the Department of Bioorganic Chemistry and the University of Halle performed experiments with transgenic Arabidopsis plants which were genetically modified to express a protein in the cytosol, the liquid inside the cells. This protein breaks down and releases light energy after it has bound to calcium ions. The emitted light energy correlates with the respective concentrations of calcium ions. In this way, intracellular changes of calcium levels can be determined directly. Moreover, these processes can be made visible in the plants by applying a highly sensitive camera system which uses charge-coupled devices (CCD). Every bite of a caterpillar made certain leaf areas shine. The immediate reaction of the plants was clearly visible. It was very important for the researchers to show that the calcium signal is a systemic process, rather than a local one, as it wanders from the attacked leaf to neighboring leaves within a few minutes to trigger the subsequent defense responses. The scientists succeeded in visualizing this dynamic process.

How calcium signals are elicited in separate areas of plants is not yet fully understood. However, the scientists speculate that the electric signals which are transmitted via the vascular system of plants, so-called vascular bundles, play an important role. There are no significant differences between calcium signals which are elicited by mechanical wounding and those which are triggered by feeding caterpillars. Surprisingly, the application of larval oral secretions inhibited the transduction of calcium signals to neighboring leaves in the experiment. Of general importance for systemic calcium signaling is the wounding of the vascular system of the leaf, which is also responsible for the internal transport of water and nutrients in the plant.

This study demonstrates that calcium signals, which are necessary for eliciting plant defense responses, and their spatial and temporal expansion can be visualized. Moreover, the scientists showed that calcium signaling can be studied directly in intact plants in different physiological and ecological contexts, which helps us to better understand its role as a secondary messenger in plants. [AO/AM]
Deceptive flowers

Flowering plants emit odors in order to attract pollinators. Pollinators are rewarded with sweet nectar for their reproductive assistance. However, some female moths pollinate the flowers and lay their eggs on the leaves of the same plant afterwards. From these eggs, voracious larvae hatch and threaten the survival of the plant. One example is the tobacco hornworm *Manduca sexta*, a moth that visits and pollinates the flowers of *Nicotiana attenuata*, a wild tobacco species. Its larvae can cause devastating damage. As scientists from the Department of Molecular Ecology found out, the concentrations and amounts of floral scent and nectar vary in natural populations of *Nicotiana attenuata*. Some individual plants do not secrete any nectar at all. These plants cheat floral visitors by initially attracting them and then denying the larvae a reward for pollination services.

To study both traits, scent and nectar, independently and simultaneously, the scientists used plants that had been genetically altered to not produce benzylacetone, the main component of the floral scent, or nectar. A third group of plants could synthesize neither benzylacetone nor nectar. These plants were modified by using an RNA-interference-based transformation technique (RNAi). The assessment of the experimental data revealed that both scent and nectar ensure that flowers are visited by pollinators more often than plants that lack these traits. Interestingly, scent and nectar had different effects on the pollen transfer service offered by three different pollinators. On the other hand, scent as well as nectar directly influenced oviposition by female *Manduca sexta* moths. The amount of nectar more than scent affected the decision of female moths to lay their eggs, and therefore more *Manduca* eggs were found on plants that produced large amounts of nectar. Some plants are cheaters and only pretend to be offering a reward. They benefit from nectar-producing neighbors and cheated pollinators, thereby substantially reducing herbivory.

Flowers face many challenges. They have to ensure outcrossing and reproductive success and depend on different pollinating species, all of which have different preferences and behaviors. At the same time, flowers must also make sure that moths won’t lay too many eggs on the leaves of a single plant. The combination of these floral traits, scent biosynthesis and nectar production, requires a certain fine-tuning to maximize the fitness of a plant. [AO]

Danny Kessler studies *Nicotiana attenuata* plants in their natural habitat in the Southwest of Utah, USA.

Friend or foe: A *Manduca sexta* moth pollinates a tobacco plant. Its larvae feed on tobacco. Photos: Danny Kessler

Original Publication:
Prof. Dr. Georg Pohnert from the University of Jena is a new Max Planck Fellow at the Max Planck Institute for Chemical Ecology

Since October 1, 2015, Prof. Dr. Georg Pohnert has been a Max Planck Fellow. This honor allows him to conduct research at the MPI-CE as a guest scientist and to head of his own research group. Georg Pohnert’s research interests focus on the chemical ecology of plankton communities. The term “plankton” includes the numerous, often microscopically small organisms that float in oceans and lakes. He is especially interested in the question of whether unicellular microalgae can be considered individuals. When algal populations “bloom,” they can form huge carpets on the sea surface. The resulting entity comprises many tiny organisms which interact with each other, is highly complex and changes constantly. Each individual cell seems to have its own “personality.” What is certain is the fact that the algae communicate and interact by using chemical signals, for example, when they use pheromones for sexual reproduction, or in predator-prey relationships or for mediating microbial infection. The new research group wants to find out how heterogeneous algal populations are and how the chemical properties of individual cells influence the interactions between whole populations. [AO/AB]

Hany Dweck received the Otto Hahn Medal

With his discovery of several specialized information channels in the olfactory system of flies, Hany Dweck has contributed to a better understanding of insect olfaction. For this achievement he has been awarded the Otto Hahn Medal of the Max Planck Society. In his dissertation on the neuroecology of Drosophila melanogaster olfaction, he successfully demonstrated that vinegar flies have several highly specialized information channels and that ecologically relevant odors are recognized and further processed on the fly antenna. [AO]

Microbe-mediated adaptation to a novel diet

Scientists of the Max Planck Research Group Insect Symbiosis and the Experimental Ecology and Evolution Group found that acquiring a group of bacterial symbionts that are localized in the gut enabled fire bugs (Pyrhocoridae) to successfully exploit a previously inaccessible food source, the seeds of Malvales plants, by providing nutrients. The high species diversity observed within the group of firebugs harboring the specialized gut microbiota suggests that the microbial symbionts have been instrumental in allowing the bugs to diversify into this ecological niche and expand into the large number of species observed today. [AO/SS]

The secret weapons of cabbages: Overcome by butterfly coevolution

Larvae of butterflies, such as those of the Large White butterfly, can cause severe damage to cabbage and related plants due to their evolutionarily optimized adaption to glucosinolates. The activity and number of genes that enable these butterflies to feed on cabbage plants vary among species; an optimized detoxification of these insects’ favored cabbage host plant is the result. By sequencing the genomes of both plants and butterflies, an international team of researchers discovered the genetic basis for this arms race: Advances on both sides were driven by the appearance of new copies of genes, rather than by simple point mutations in the plants’ and butterflies’ DNA.

Original Publication:

Linking molecules to microbes

Scientists of the Max Planck Research Group Insect Symbiosis and the Mass Spectrometry Group, in collaboration with Thermo Fisher Scientific, succeeded in visualizing the distribution of antibiotics and, simultaneously, their producers in natural samples. Focusing on the defensive alliance between European beewolf wasps, Philanthus triangulum, and bacteria of the genus Streptomyces, they combined mass-spectrometric (MS) imaging with fluorescence in situ hybridization (FISH). Detecting and visualizing compounds in nature and identifying their microbial producers constitutes a first step toward being able to monitor complex interactions directly where they occur. [MK/AO]

Original Publication:

A community of soil bacteria saves plants from root rot

Root bacteria are known to improve plants’ supply of nutrients. In addition, they also protect plants from infections. During field experiments in Utah, USA, scientists from the Department of Molecular Ecology found that the right mixture of soil microbiota directly influences the survival of wild tobacco plants. Plants that had been unable to establish a protective alliance with the vitally important soil bacteria were susceptible to an infectious wilt disease that in some cases killed plants overnight. The results of the study reveal the complex ecology of plants, especially with respect to the multitude of beneficial and harmful microorganisms that interact with them. [AO]

Original Publication:
Scientists from the Institute of Organic Chemistry and Biochemistry in Prague and the MPI-CE studied the pheromone chemistry of moths and discovered a new evolutionary mechanism: A single amino acid change in a female moth enzyme is responsible for the production of new sex pheromones. Divergences in moth pheromone communication probably led to the evolution of new insect species. [AS/AO]

Original Publication:

A sex pheromone assembly line in Manduca sexta

Male crickets offer nuptial gifts to their mating partners, which may alter the females’ reproductive physiology and make them less likely to mate with other males. Researchers from the University of Exeter, UK, and the MPI-CE analyzed the proteins in the gift and found a striking resemblance to growth factor proteins. This result suggests that the protein in the gift may influence female reproductive behavior.

Original Publication:

Edible love gifts may influence female behavior

Plants produce toxic compounds in order to fend off herbivores. To make sure that these defensive substances will not harm the plants themselves, many plants add a sugar molecule to their toxins. Digestive enzymes cleave this sugar to release the toxin. Scientists from the Department of Molecular Ecology have found a toxic defensive compound of the wild tobacco Nicotiana attenuata with sugar molecules bound to it. An enzyme in the gut of the tobacco hornworm Manduca sexta removes one sugar from this toxin to convert it to a non-toxic form. This is the first time that the role of deglycosylation in detoxification as an insect counter-adaptation has been shown. [AO]

Original Publication:

Reducing the sweetness to survive

Spoorthy Poreddy studies a Manduca sexta caterpillar feeding on a tobacco plant in the greenhouse of the institute. Photo: Anna Schroll

The art exhibition with the title ARCHAIISCHE MODERNE - (Archaic Modernity) – Creations of felt and bone with works by artists Ullrich Schmidt and Roland Spieß can be visited until December 17, 2015. The exhibition is open to the public from Monday to Friday, between 9:00 a.m. and 4:00 p.m. Admission to the works exhibited in the entrance hall and the courtyards of the Max Planck Institute for Chemical Ecology is free. http://www.ice.mpg.de/ext/schmidt-spiess2015.html