# Plants and Their Secret Weapons

## Basic Research Under the Roof of Carl Zeiss

Caroline Liepert

*Carl Zeiss Jena GmbH has currently provided accommodation on its premises for two Max Planck Institutes until their own buildings in Jena are completed. Due to the implementation of a strategy focusing certain product lines on the different locations of the Carl Zeiss Group, large facilities at the Jena plant have become vacant. An area of 2,300 m² was used in 1997 to set up laboratories and offices for the Max Planck Institute of Chemical Ecology, including e.g. laboratories for classical chemistry, isotope analysis, analytical metrology and molecular biology. After the completion of an initial study, the Consulting and Engineering business unit of Carl Zeiss performed the overall planning procedure and subsequently monitored the construction work. Only ten months after the signing of the contract, the laboratories were officially handed over to the user.*

*At the same time as this project, discussions and work were initiated on the second Max Planck Institute on the Zeiss premises: the Institute of Biogeochemistry. State-of-the-art laboratories and offices with a surface totaling 2,600 m² were planned and built for this organization. The institute started its work after only nine months, in June 1998.*

Where huge machines used to operate for the electroplating of mechanical components such as microscope stands, state-of-the-art, computer-controlled equipment has now been installed for the separation and identification of natural substances and for the reproduction and research of genetic sequences. These are only a few examples of the instruments used by the Max Planck Institute of Chemical Ecology in Jena for its work. Founded in September 1996 as the second Max Planck Institute in Jena, the organization now has a staff of approx. 130 employees from Germany and abroad working in four scientific departments and in general service teams. The scientists at the institute are exploring the question as to how live organisms communicate with their environment via chemical messengers. What appears to be a pretty straightforward subject at first glance is in fact a highly complex interaction system at different levels – molecular, cellular and organismic – and one which can only be comprehensively investigated in an interdisciplinary approach. It is therefore no surprise that ecologists, biochemists, population geneticists and experts from organic and analytical chemistry work closely together at the institute.

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### Chemical self-defense of plants

Plants are the focal point of the institute's scientific studies. Their large number of herbivorous enemies has led not only to the growth of thorns and prickles by which many plants keep unwanted visitors at bay, but also to the evolution of effective chemical defense mechanisms. When under attack, plants frequently respond by intensifying their synthesis of specific substances which have an inhibitory or toxic effect on insects. The roots of tobacco plants (*nicotiana*), for example, produce the familiar nicotine, a neurotoxin which may account for as much as 10 % of the leaves' dry

**Fig. 1:**
Gas chromatography laboratory in the molecular ecology department.

**Fig. 2 (in the text):**
Caterpillar of the owlet moth on cotton.

Fig. 3:
Caterpillar of the tobacco hawkmoth on tobacco.

Fig. 4 (large photo):
Collection of odorous substances of a corn plant.

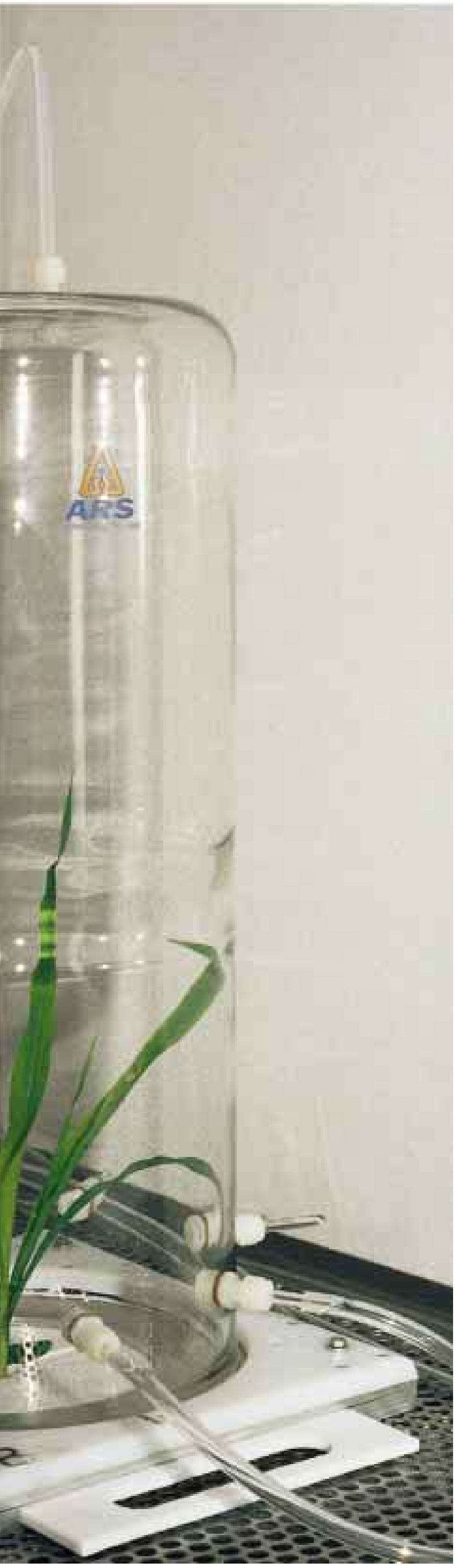
matter. Such a diet is lethal for many insects. It is no accident, therefore, that nicotine is also used as a pesticide. What signals indicate infestation by harmful insects and how are the stimuli transmitted at a molecular level inside the tobacco plant – these are questions which the scientists at the Max Planck Institute are trying to resolve. Beyond this, they are also interested in the ecological consequences of such chemical defense mechanisms. Do tobacco plants produce less seed and, as a result, fewer potential descendants if they have to use more of their metabolic energy for defense than non-infested plants of the same species? These issues are being investigated in laboratory and field experiments.

Figs 5 and 6:
Investigation of nicotine production in tobacco plants.

A further group of secondary substances present in plants which play an important role for defense against herbivores or pathogens and are being studied in depth at the institute comprises glucosinolates or thioglucosides, the parent substance of mustard oils with the pungent taste or odor we are all familiar with from mustard, horseradish or capers. Little is known to date about the biochemistry and genetics of glucosinolate biosynthesis, despite its previously mentioned practical relevance for mankind. Using state-of-the-art biomolecular and genetic methods, the scientists are trying to throw light on the control of the metabolic pathways and to reveal the importance of these substances for the interaction between plants and their herbivorous or pathogenic enemies.

## An odorous cry for help

Plants are also able to exchange information via the air – in the form of volatile cues which act as SOS signals – thus protecting themselves against herbivores. The production and emission of odorous substances induced by eating insects also attracts their enemies (insectivores). This means that the plants' odors serve as markers that point the way toward the prey. This phenomenon is also interpreted as the "plant's cry for help". However, these plant odors not only permit insectivores to find their prey more easily, but also induce non-infested plants of the same species in the direct neighborhood to



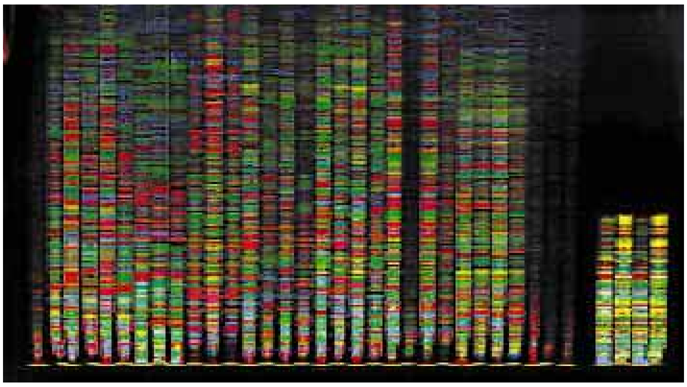


**Fig. 7:**
DNA analysis using a sequencer.

intensify the synthesis of these odorous substances. The importance of this discovery, e.g. for plant protection, is evident. Apart from the content of the volatile cues, the scientists at the Max Planck Institute are primarily interested in the molecular mechanisms of the signal cascade inducing the biosynthesis of odorous substances.

## Genes for chemical signals

The infestation of plants by herbivores triggers a complex mechanism in the plant's organism. To understand the basic functional processes of the plant's self defense, it is also essential to identify and characterize the resistance-specific genes involved in the synthesis, storage, identification and metabolism of chemical cue molecules. State-of-the-art biomolecular and genetic methods enable the scientists at the institute to provide information on which areas of the plant's genome are activated or deactivated by infestation. The researchers hope that – irrespective of the considerable potential for applications in agriculture and forestry – the findings will also give them an insight into the processes in which these interrelations of organisms evolved in the past.

## Max Planck Institute of Biogeochemistry

Gaschromatography MS laboratory of the Max Planck Institute of Biogeochemistry. The institute studies the behavior of ecosystems and biogeochemical processes in varying climatic conditions. The aim is to understand complex overall systems composed of a large number of interacting subsystems which influence each other. Ultimately this also includes gaining an insight into whether and to what extent nature is still able to compensate for human intervention. For this purpose, systematic experiments must be conducted for the investigation and modeling of functional connections and interactions, followed by the combination of the results with e.g. paleo-data to assess the forecast potential of such models.