Max Planck Institute
of Molecular Plant
Physiology

MAX-PLANCK-GESELLSCHAFT

Science and Research

"Since the institute was founded in 1994, as one of 18 institutes in the new Bundesländer, the main emphasis of the institute has shifted from the analysis of central metabolic pathways combined with the analysis of gene function to the development and implementation of phenotyping technologies and system approaches. This Systems Biology approach is driven by a close interaction between experimental and computational scientists who work side by side in the institute." (Founding Director Prof. Dr. Lothar Willmitzer)

The **Max Planck Institute of Molecular Plant Physiology (MPI-MP)** investigates metabolic and molecular processes in cells, tissues, organs and whole plants. The overall goal is to understand how growth and metabolism are regulated, to learn how they respond to environmental factors, and to unravel genetic factors that underlie these processes and responses. To achieve this, it is not only necessary to understand the functions of individual genes, but also the molecular details of individual processes like the uptake of nutrients, the structure, storage, transport and mobilisation of plant components, and the regulation of individual processes. It is also essential to learn how these different processes interact in networks, and to develop approaches that provide quantitative information and a predictive understanding of these complex networks.

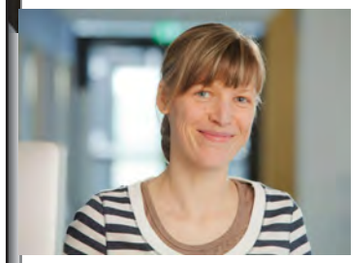
People and Stories

Beginning with only 16 people in 1995 the institute has grown rapidly, and now has about 400 employees including currently 140 post-docs, 110 doctoral students and 43 technical assistants. Thirty nations are represented. About 54% of the employees are female.

Since the institute was founded a remarkable number of scientists from the institute have taken up senior positions at universities or other scientific institutions, either in Germany or abroad, while others have moved on to jobs in industry or have founded their own companies.

Each year we play host to scientific guests from all corners of the world who come to spend their sabbatical at the MPI-MP. For example, Joseph Hirschberg from the Hebrew University of Jerusalem, Sabeeha Merchant from the University of California (Los Angeles), Bob Buchanan from the University of California (Berkeley) or Eric Lam from Rutgers State University (New Jersey) are among the eminent scientists we have hosted. The three last-mentioned have won a Humboldt Research Award.

A central aspect of the MPI-MP is its internationality. Our multicultural atmosphere provides a very rewarding experience for all staff at the institute and prepares young scientists for a career in research institutions worldwide.
(Prof. Dr. Ralph Bock)



Birgit Schäfer
Personnel Administration Department (since 2000)

A prime responsibility of mine is to help foreign staff integrate in Germany and to offer support to short-term guests. In order to facilitate their start here I offer assistance in obtaining a residence permit and opening a bank account as well as providing advice on day to day local life. I enjoy all aspects of my work, however, particularly interacting with the multinational staff which affords me the opportunity to widen my outlook on life, encounter different cultures and develop novel skill sets.

Sandra Stegemann
Technician (since 2004 in the institute)

In 2004 I moved with the whole working group to Potsdam. First I was skeptical about my decision to leave Münster but soon I was impressed by the facilities, the high-tech equipment and the number of different nationalities working together in this institute. I like the opportunities Potsdam has to offer: the palaces and gardens and the nature and lakes around Potsdam. I never regretted my move to Potsdam.

Organisation and Cooperation

“Our institute is not arranged in a strictly hierarchical way but could be characterised as horizontally structured. This allows more flexibility, promotes cooperation at the institute level, aids integration of guest groups, and amplifies the scientific autonomy and development of junior scientists.” (Prof. Dr. Mark Stitt)

The Max Planck Institute of Molecular Plant Physiology is organised in three Departments headed by the directors Lothar Willmitzer, Ralph Bock and Mark Stitt. (from R to L)

The basic organisational and scientific units are the research groups, known in German as “Arbeitsgruppen” (AGs). Each department possesses several AGs. Beside the departments there are infrastructure groups – Transcript-Profiling, Applied Metabolome Analysis or Bioinformatics – and service units like the Green Team and the Microscopy Unit. Three independent junior research groups, appointed directly by the Max Planck Society, and two cooperative research groups of the University of Potsdam complete the scientific team. Close cooperation is encouraged between all AGs with respect to scientific projects, development of methods, instrumentation and technology platforms, seminars and student supervision.

In addition to the administration team, the institute employs a number of service staff ranging from IT and facility management to public relations.

Salma Balazadeh
Group Leader (since 2004 in the institute)

A twist of fate, while working on my MS project in Iran, presented me with the great opportunity to continue my education in one of the world's leading research institutes, MPI-MP in Germany. Many factors persuaded me to stay in Germany, the country is well-known in many fields of research, and is particularly famous for its leading technologies and internationally competitive labs in biology, biotechnology and biochemistry. The academic knowledge and experience gained by working in an excellently equipped laboratory were incredibly valuable. In addition to the scientific atmosphere, the cooperation and the sense of friendship between the members of the group and the institute which augmented our research findings made my academic life enjoyable and fruitful. I am certain that for me who wanted to pursue a science-related career, Germany was the best option.

John Lunn
Principal Investigator (since 2002 in the institute)

I moved to the MPI-MP about 10 years ago to follow my interests in plant metabolism. The institute is a centre of excellence in this field, bringing together world-leading researchers and cutting edge technologies. It is home to a friendly and vibrant community of students, post-docs and visiting scientists from around the globe, making it a stimulating and enjoyable place to work. The campus is on the edge of the historic and beautiful city of Potsdam, surrounded by forests and lakes but also close to the big-city attractions of Berlin, so there is something here for everybody.

Dmitri Schmidt
Masters Student

During my academic degree in biotechnology I wanted to improve my skills in proteomics and plant science. Hence, I was very pleased to get a job opportunity at the MPI-MP. I was very satisfied with the support from the institute during my bachelor thesis, which is why I decided to carry out my master thesis at the MPI-MP. What makes the institute so special are its top-equipped laboratories, and the very high level of competence and helpfulness of people.

Christin Höpfner
Gardening Apprentice

Practical skills first, theoretical knowledge later, that is my motto. Therefore, I decided to complete an apprenticeship as a gardener before studying landscape architecture. What fascinates me most about my job is the possibility to gain insight into the activities of an excellent research institution. It is very interesting to cultivate tropical plants like rice or sugar cane and it is unusual for a gardener to grow a weed such as Arabidopsis. Something special is the opportunity to plan our own flowerbed because it gives me the chance to be creative and to implement my knowledge.

Prof. Dr. Sabeeha Merchant
University of California Los Angeles, Member of the National Academy of Science of the USA

I had visited the MPI in Golm twice previously and was impressed with the vitality and intellectual engagement of its researchers. I very much enjoy my trips to Germany, especially some of the white wines (which I drink every day), and so with my interest in photosynthesis and chloroplast biology, this institute was a good fit for my sabbatical. At the University of California, Los Angeles (UCLA), we have excellent collaborations and resources for genomics, transcriptomics and proteomics, which we have exploited in the past few years, but we are at the point where the techniques of metabolomics, for which the Max Planck Institute of Molecular Plant Physiology is renowned, are very valuable.

People and Stories

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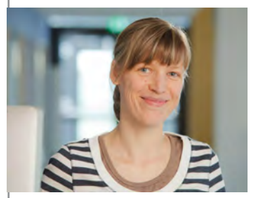

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Imagination and Innovation

In the long run our goal is to develop a comprehensive, systems-level understanding of plant growth. To link plant growth and metabolism, the institute maintains a strong interest in understanding the genetic and physiological basis of biomass formation and heterosis. In addition, unique genetic resources have been developed to address another important effect relevant to plant growth: hybrid incompatibility. This research direction links plant physiology with evolutionary genetics and population genetics, and will close the gap between the research on growth and bioenergetic pathways in chloroplasts and mitochondria, and the work on experimental genome evolution pioneered at the MPI-MP.

Current efforts are centred on unravelling a set of complex processes that are of particular relevance to plant biomass: the bio-energetic pathways, macronutrient acquisition, nutrient signalling and resource allocation.

To grasp the complexity, it is essential to determine molecular and phenotypic parameters at different functional levels, and to analyse the complex data set against the background of existing biological knowledge.

"A detailed understanding of plant growth represents one of the greatest challenges in plant physiology. The institute is very well prepared to accomplish this challenge."
(Prof. Dr. Lothar Willmitzer)

Research: Strategy and Policy

"In its initial years, the MPI-MP made major contributions to technology development, developing methods and resources that are now widely used in plant research throughout the world. In the last years, the institute shifted towards using the combined power of our profiling techniques, genetic resources, physiological methods, and bioinformatics tools to answer major biological questions."
(Prof. Dr. Mark Stitt)

Biomass acquisition is a highly complex process that is influenced by an enormous diversity of endogenous and exogenous factors. Macronutrient availability, uptake, distribution and storage of substances, the activities of the bioenergetic pathways and numerous abiotic factors, such as light, temperature and water availability and their impact on cellular growth play a major role in the growth of the plant. Developmental aspects of growth, like pattern formation, cell division rates, cell expansion and organ development interact with these factors. The institute has chosen metabolism as the point of entry to understand how plant growth is organised.

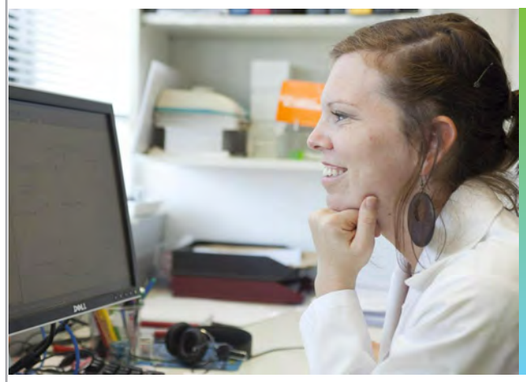
While the research strategies in the institute vary from group to group, they often involve one or more of the following complementary approaches:

- **Reverse genetics** is used with increasingly sophisticated methods to achieve spatially- or temporally-resolved changes in gene expression, and to optimally modify plastid gene expression at all levels
- **Natural genetic diversity** is used as a tool for multisite perturbation of complex networks, to search for metabolic phenotypes that may be predictors of complex traits like growth and heterotic yield gain, and to identify loci, genes and polymorphisms that contribute to the genetic regulation of metabolic traits
- **Large time series or comparisons of multiple states** are used during physiological or environmental perturbations
- **Network analyses** are used alone or in combination with published data to identify candidate genes which then are subjected to detailed functional analysis
- **Analyses of molecular and metabolic traits combined with studies of integrative traits**

Models and Predictions

One process that groups from all three departments have begun to tackle comprehensively at the systems level is photosynthesis as a key bioenergetic process in plants. The unicellular model alga *Chlamydomonas reinhardtii* was chosen for systems biology approaches. To work on the more complex problem of the relation between metabolism and growth in higher plants Arabidopsis is used, along with pilot projects on selected crops like maize and tomato.

The goal is to understand and ultimately model the complexity of photosynthesis and its interactions with other cellular metabolic networks and its dependence on the abiotic environment. This will eventually enable us to grasp and model the relationship between metabolism and growth.



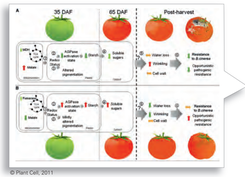
"It is a continuing challenge to integrate the oceans of data and develop models of plant growth processes that come up with testable predictions, which, in turn, can be scrutinised by rigorous experimentation."
(Prof. Dr. Lothar Willmitzer)

Results and Excellence

"Over the last years, scientists at the MPI-MP published about 200 articles per year, in 64 journals. Many papers involve interactions between the three departments, the independent research groups, the infrastructure groups and the guest groups, and are highly cited." (Prof. Dr. Ralph Bock)

Although the main mandate of the institute is to perform cutting-edge basic research in plant biology, which ends up in scientific breakthroughs and publications, we also continue to explore the potential of our discoveries and develop methods in applied research. New lines of applied research at the institute have been established. Some examples are the application of metabolite profiling techniques in biomarker discovery e.g. for diagnosis of human diseases, the development and commercialisation of a cyvorobot for sample handling, a cutting-edge spectroscopic apparatus for photosynthesis research, the exploration of the potential of chloroplast genetic engineering for the design and production of novel pharmaceuticals e.g. edible vaccines and next-generation antibiotics, and the development of new tools for algal biotechnology.

The effectiveness of our research approaches is reflected in a series of publications which deal with the following fields of research:



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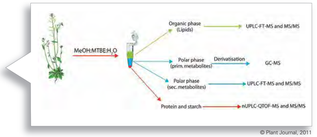

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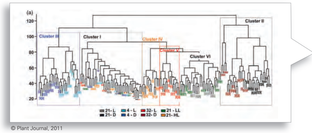
The development of a new approach in metabolomics using differential stable isotope labeled metabolomes: Giavalisco, P., Li, Y., Matthes, A., Eckhardt, A., Hubberten, H.M., Hesse, H., Segu, S., Hummel, J., Köhl, K., Willmitzer, L. (2011). Elemental formula annotation of polar and and lipophilic metabolites using (13) C, (15) N and (34) S isotope labeling, in combination with high-resolution mass spectrometry. Plant Journal 68: 364-376



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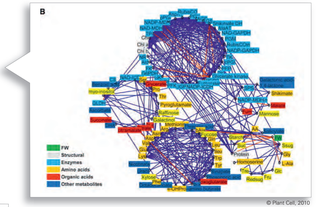

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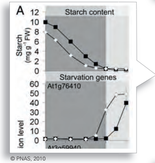

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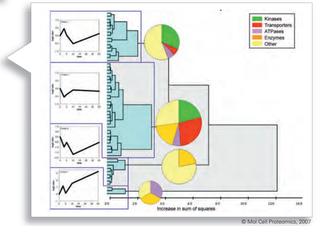

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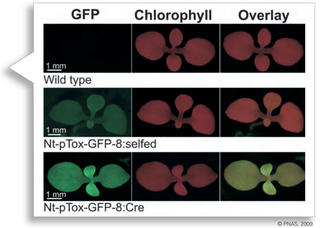

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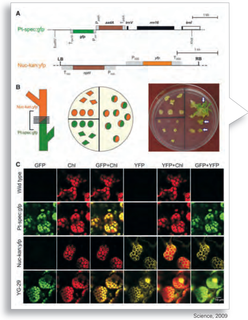

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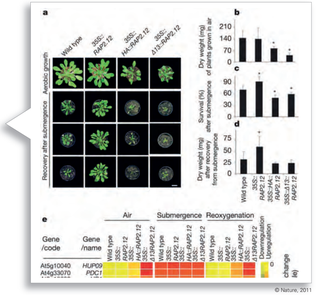

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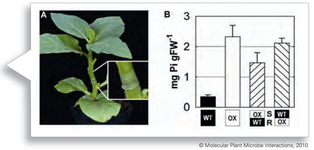

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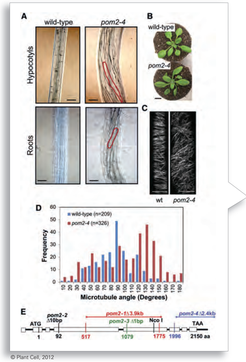

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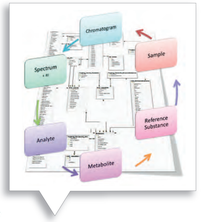


The institute has a broad range of data bases available which is continuously developed and is widely used throughout the world, including the MapMan ontology and tools for analysis and display of 'omics data:

http://www.mpimp-golm.mpg.de/databases

You can find a full list of our publications on our website:

http://www.mpimp-golm.mpg.de

Young and International

Asdrúbal Burgos
IMPRS student from Mexico

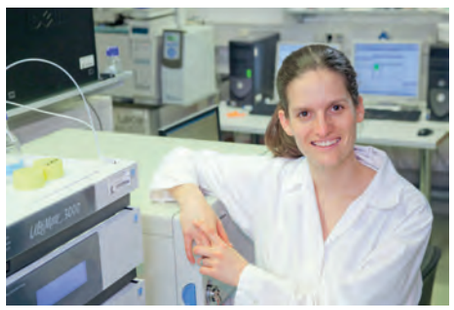
I came to the MPI-MP because this is an institute full of experts in plant science, and especially plant metabolism, which is the most fascinating topic for me. In my everyday work, when I look for relevant papers, I always end up finding authors from the institute. Then I know I'm in the right place.

Christoph Thieme
PhD student from Germany

Bioinformatics means tackling complex questions in biology using methods from mathematics and computer science. Working at the MPI-MP provides a great opportunity to develop and apply such methods hand in hand with plant biologists. As such, working in bioinformatics at the MPI-MP is more than just "dry theory" and allows me to work on, and hopefully solve, real problems. From the very first day I enjoyed working with the friendly people in this great scientific atmosphere. Furthermore, the surroundings with all the historic places, nice parks, and green forests allow me to replenish energy for the next scientific challenges.

Yan Li
IMPRS student from China

Golm, not far away from Berlin, is a beautiful and quiet town. It is a perfect place to do science. The MPI-MP is one of the world's most famous institutes to do plant physiology research. I am interested in "OMICS" research, which is well established in Prof. Lothar Willmitzer's lab. IMPRS offers us a wonderful platform to exchange ideas and experiences within the institute, and many of the daily issues are taken good care of by our IMPRS coordinator, Dr. Ina Talke. This is a "wonderland" for science and life!



Tabea Mettler
IMPRS student from Switzerland

During my PhD, I wanted to learn the most up-to-date techniques to quantify metabolites and proteins, and work with algae. I was very glad to find that all were possible at the MPI-MP and therefore applied here. After arriving, I found Potsdam to be a really charming city. In addition, the landscape of Brandenburg State is formed by rivers and lakes, inviting all sorts of sport and leisure activities. This offers many opportunities for a balanced life!

It is always gratifying and refreshing to follow the growth of young scientists during their time at the MPI-MP. The doctoral programme aims to support them both in their research and career development.
(Dr. Ina Talke, IMPRS Coordinator)

Doctoral students are an integral part of the research community at our institute. They join us after having completed a master's (M.Sc.) or equivalent degree in Germany or abroad. Our group leaders and other senior researchers guide the young scientists in their research projects and studies.

Within our doctoral education programme, we collaborate closely with the Institute for Biochemistry and Biology at the University of Potsdam. Most of our doctoral candidates are registered as students at the University of Potsdam and will submit and defend their theses at its Science Faculty. The PhD theses can be written and defended in English or German.

IMPRS
Primary Metabolism and Plant Growth

A prominent example of this collaboration is the International Max Planck Research School "Primary Metabolism and Plant Growth" (IMPRS-PMPG). Based on the Max Planck Society's IMPRS initiative, the IMPRS-PMPG offers talented young scientists the possibility to pursue doctoral research in a structured programme with an interdisciplinary scientific focus. The projects of our IMPRS students aim to elucidate plant growth and biomass acquisition from a physiological point of view with primary metabolism as a starting point. Systems-oriented research approaches are followed, combining cutting-edge analytical techniques, molecular phenotyping (-omics) technologies and physiology with bioinformatics and modelling approaches.

All our doctoral students are financially supported by a stipend or employment contract for three years, with a possibility of extension up to four years. During this time they sharpen their scientific profile and participate in many other activities – seminars and lectures, courses on transferable skills such as scientific writing or team dynamics, and the student-organised "Plants and People" conference.

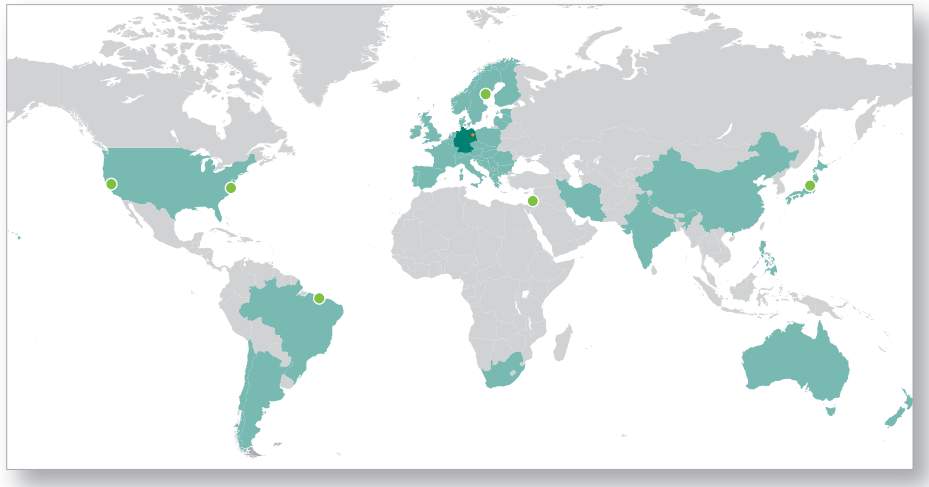
Many of our young scientists come from abroad – Poland, China, Chile, Brazil, India, to name but a few countries. This international atmosphere and the excellent research conditions make our institute an attractive place for doctoral studies.

Network and Interchange

At Home…

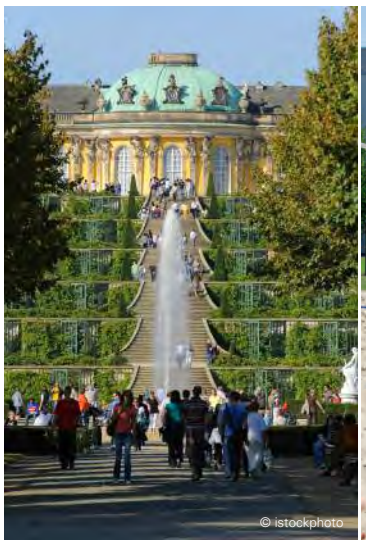
The MPI-MP maintains close links with the neighbouring University of Potsdam via many joint projects, and by hosting a small number of groups who have full access to the institute's facilities. All three directors are Honorary Professors at the University of Potsdam. Several of the AG-Leaders are involved in teaching and preparing for their habilitation at the University of Potsdam.

Several research groups are joined in a collaborative research programme ("Sonderforschungsbereich") supported by the Deutsche Forschungsgemeinschaft (DFG), or participate in the Plant 2030 (former GABI) programme, which is financed by the German Federal Ministry of Education and Research (BMBF). Groups also participate in international projects like ERA-Net and other European programmes.



…and Abroad

In addition to the networks established in the framework of various individual research projects, the institute has established various international co-operations. Special relationships exist for example to the Riken Institute in Japan, the Umeå Plant Science Centre in Sweden, the Weizmann Institute of Science and the Hebrew University of Jerusalem in Israel, the Instituto Nacional de Ciencia e Tecnologia do Bioetanol in Brazil, the Boyce Thompson Institute at Cornell University, and The Arabidopsis Information Resource (TAIR) at Stanford in the USA.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Neighbourhood and Surroundings

Bright Minds Next Door

The institute is part of the Science Park Potsdam-Golm. Aside from the MPI-MP, the campus includes two other Max Planck Institutes (Colloids and Interfaces, and Gravitational Physics), two Fraunhofer Institutes (Applied Polymer Research and Biomedical Engineering), a start-up centre called Go:In and the Golm campus of the University of Potsdam. Since the mid-1990s the Potsdam-Golm Science Park has developed in scientific and economic terms into one of the most innovative and promising locations in the federal state of Brandenburg.

More than 2,500 people are employed at the Science Park, alongside 7,000 students enrolled in the Faculties of the University of Potsdam that are located in Golm. A professional management assists the development of the Science Park through targeted expansion of the infrastructure and combines the strengths and interests of all institutions, institutes, organisations and businesses located at the Science Park. Above all, companies interested in moving into the park and young entrepreneurs benefit not just from the existing networks but can also rely on the experience and support of the park's famous institutes and personalities.

"The combination between leading international research institutions, start-ups, research-based production and the University of Potsdam makes the Potsdam-Golm Science Park a location with extraordinary potential for innovation."

(Prof. Dr. Ralph Bock, Chairman of the Steering Committee of the Science Park Potsdam-Golm)

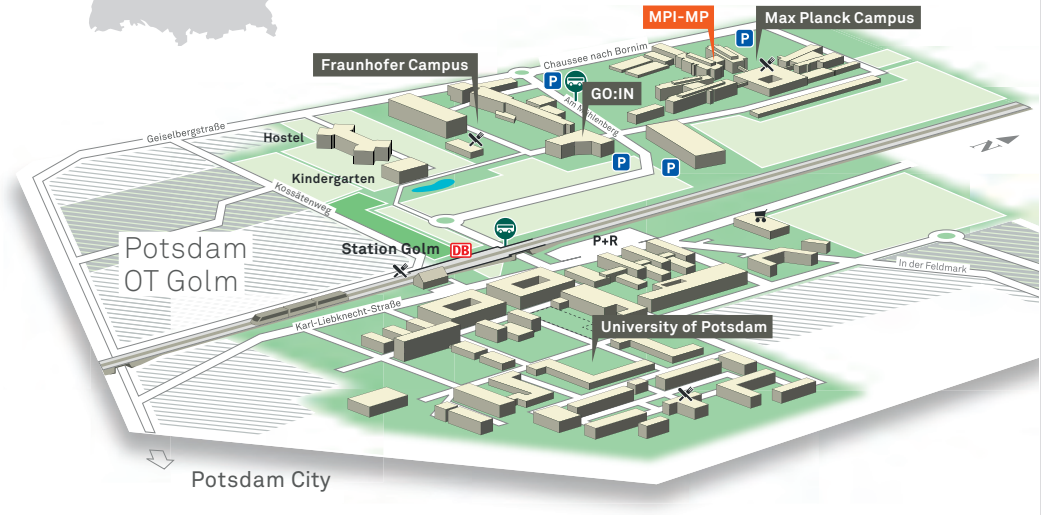
Nature and Outdoors

Great science, research and business opportunities are not the only attractions of the Potsdam-Golm Science Park. The location also offers a pleasant working environment on the edge of a nature conservation area and a good quality of life in the cities of Potsdam and Berlin and their surrounding areas. There are many cultural, educational and leisure attractions for the whole family, including art exhibitions, various gastronomic establishments, sports facilities and open days. The Science Park is extremely family-friendly with a brand new purpose-built child care centre on campus.

→ **www.wissenschaftspark-golm.de**
→ **www.potsdam.de**

Where and how

Potsdam/Golm close to Berlin



Station Golm – How to get there from Potsdam
By bus: Number 605, 606, 612 or X5 from Potsdam main station
By regional train: RB 21 or RB 20 from Potsdam main station
By car: e.g. on the A10 – take exit Potsdam Nord or Leest – direction to Golm.
The University compound is situated in front of the station on Karl-Liebknecht-Straße.

For more details about public transport, please consult the homepage of Verkehrsbund Berlin-Brandenburg (VBB): **www.vbb-fahrinfo.de**

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