



**Bayer Campus Monheim**

*Think Tank  
on the Rhine*



## *Dear Readers,*

Around 40 years ago, Bayer concentrated its research activities on all aspects of crop protection on the outskirts of Monheim – 15 kilometers from the company headquarters in Leverkusen and literally on a green field. Since then, this location has developed into the world's most renowned agricultural research center: the Bayer Campus Monheim, the crop protection laboratory of the future, and the headquarters of the Crop Science Division at Bayer. Approximately 1,000 employees in research and development and 1,000 of their colleagues in other areas make a significant contribution to laying the groundwork for a better future – for people all around the world.

In 1979, a certificate attesting to the company's dedication to feeding the world and protecting the environment was sealed into the cornerstone of the Monheim site.

And while these goals still hold true today, our world has changed significantly in the intervening years and now presents us with much more complex challenges. The number of people on our planet has nearly doubled since the 1970s. At the same time, the already scarce amount of cropland available to us has steadily declined as a result of climate change and increasing urbanization. Turning the vision of Bayer – Health for all, hunger for none – into reality always requires brilliant new ideas and innovations.

In this spirit, employees from 40 different nations work together on the Monheim Campus. With their creativity and expertise, their commitment and passion, and the diversity of their experiences, they break new ground in agriculture – and thus also ensure security, transparency and sustainability.

In this brochure, we will tell fascinating and sometimes unexpected stories about the work some of our colleagues do. We put their work into greater perspective and explain what "Science For A Better Life" means in specific terms. On that note, we hope you find this brochure to be an enjoyable, interesting, and insightful lecture, and we look forward to welcoming you personally to the Bayer Campus Monheim.



**Martin Zeller**

Site Manager  
Bayer Campus Monheim

**“Turning the  
vision of Bayer  
– *HEALTH FOR ALL,  
HUNGER FOR NONE* –  
into reality always  
requires brilliant new  
ideas and innovations.”**

Martin Zeller

*Martin Zeller has been site manager of the Bayer campus in Monheim am Rhein since March 2019. The engineer has worked for Bayer for more than 30 years, including a six-year assignment in Shanghai.*





## What *drives us*

Securing food for a growing world population while at the same time reducing the environmental impact of farming: These are the big challenges at Bayer in Monheim am Rhein.

### 08 ABOUT US / **FROM MONHEIM TO THE WORLD**

Global control center and creative think tank in one: Solutions for a sustainable future for farming have been created here on the Rhine – for more than 40 years.



# Where the standards are set

At the headquarters of the world's largest agricultural company, Bayer is conscious of its responsibility to shape the future of farming through innovation – sustainably, safely and transparently.

## 16 RESEARCH & DEVELOPMENT / **STRONGER TOGETHER**

Head of R&D Dr. Bob Reiter talks about future research tasks at the Science Division of Bayer.

## 22 EXPERIENCE / **20,000 CITATIONS**

After 40 years with the company, world-renowned resistance researcher Dr. Ralf Nauen is a good example of scientific expertise in the Crop Science Division at Bayer.

## 26 INNOVATION / **STRATEGIC FROM THE START**

How early crop protection research benefitted from one of the world's largest compound libraries.

## 32 DIGITIZATION / **KNOWLEDGE IS POWER**

Data science facilitates not only the development of new active ingredients but also the formulation of products and their application in the field.

## 36 TRANSPARENCY / **BUILDING TRUST**

Pioneering act: Bayer offers insight into studies, laboratories and testing stations.

## 40 SAFETY / **STRICT STANDARDS**

Strict standards for residue analysis protects people and animals (including bees, of course).

## 46 SUSTAINABILITY / **MEASURABLY BETTER**

Commitment to a reduced environmental impact from farming includes our own footprint.

## 52 RESPONSIBILITY / **ENABLING SECURE INCOMES**

By 2030, Bayer will make it easier for 100 million small farmers to access know-how, products and services.

# Our Bayer campus in Monheim

Roughly 2,000 employees from more than 40 countries work together in an area covering 65 hectares in Monheim. Here they find the power to change things and a culture shaped by a passion for innovation.

## 58 LOCATION / **SPACE FOR IDEAS**

Unique surroundings are a magnet for talent and an ideal setting for groundbreaking results. Employees and interested members of the public can find out and experience here what makes the Bayer campus in Monheim so special – from the daycare center to open house day.

## 62 OVERVIEW / **AT HOME ON CAMPUS**

Finding your way around 65 hectares is a challenge. Our map shows you how to get to your destination.



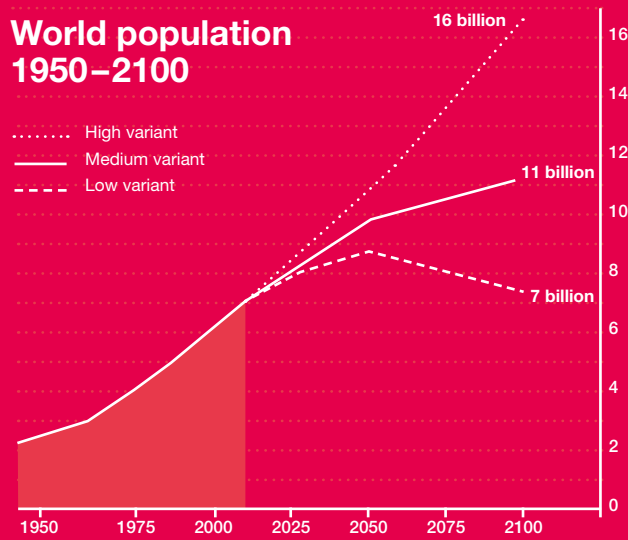
# What

# *drives*

# *us*

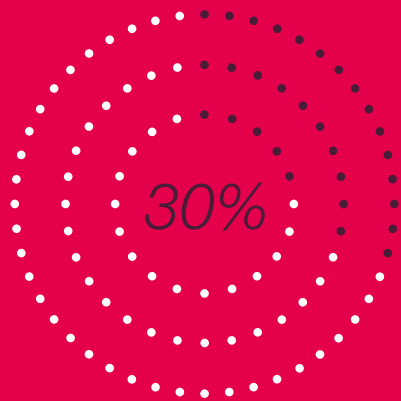
*Securing the food supply for a growing  
world population and reducing the  
environmental impact of agriculture:  
These are the big challenges of our time.*

## World population 1950–2100



# 10 million

**hectares of farmland become unusable every year – due to over-intensive cultivation as well as over-fertilization, salinization and erosion. Climate change will worsen the problem further.**




Around 30% of the world's working population is now employed in farming worldwide – a total of more than one billion people.



# From Monheim *to the* *world*





*Providing food to a growing world population and sustainably reducing the environmental impact of agriculture while also protecting crops – this supposed paradox is what the Crop Science Division at Bayer aims to resolve. This complex project is managed and driven by innovation in Monheim am Rhein.*

*The Bayer campus in Monheim combines a spirit of creative research with agricultural expertise and visionary technologies in a unique way.*

When Bayer was looking for a new location for its crop protection activities in the 1970s and chose Monheim am Rhein, the world of agriculture was a different one. There were around four billion people living on the planet – about half as many as today. And the amount of arable land available per capita, at around 5,200 square meters, was about twice as large. The challenge of supplying a growing world population with enough food has therefore not diminished since then, but instead has become considerably more demanding.

#### **Arable land – a scarce resource**

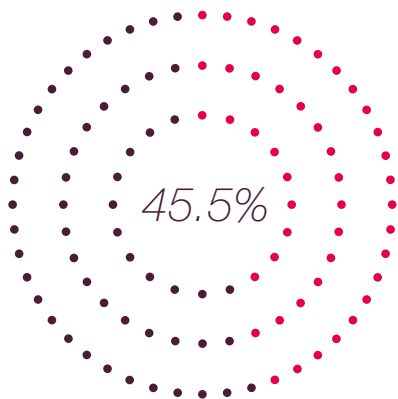
In addition to the pests, weeds and plant diseases that can destroy entire harvests, the soil itself poses a problem: In all, arable land accounts for no more than three percent of the earth's surface. But only a scant one fifth is available for cultivation of plant-based food; the rest is reserved primarily for the production of animal feed or biofuels. And fertile soil – already in short supply – is becoming increasingly scarce: Year after year, over-intensive cultivation as well as over-fertilization, salinization and erosion render tens of millions of hectares of farmland unusable – climate change and the accompanying droughts and floods will worsen these conditions further.

By 1974, the company had already given itself a second logo alongside the Bayer cross: a green linden leaf with the words “Bayer researches for environmental protection.” The general public was just beginning to become ►



Crop Science  
research budget:

**€2.0  
billion**



Share of Bayer  
Group sales

aware of the issue. Terms like “sustainability,” “climate protection” and “global warming” were not part of the general vocabulary at the time as they are now, and Greta Thunberg’s parents had not even started school. Greenpeace International itself only came into being in 1979 through the merger of several national initiatives – at the same time the cornerstone was laid in Monheim for the Crop Protection Center, today’s Bayer campus in Monheim.

#### Headquarters and central research site in one

The business affairs of the world’s leading agricultural company are now managed from this campus. In addition to its function as the headquarters for the division, Monheim is also a central research site – a think tank dedicated to the Bayer mission of “Science for a better life.” And indeed, some 1,000 scientists from all relevant disciplines are working together here to develop cutting-edge and sustainable crop protection solutions that improve the lives of people around the world. To properly appreciate their contribution, just consider that if they were entirely without crop protection, global crop yields would be on average around one-third smaller. Depending on the crop – rice or potatoes, for example – the input would drop by a full two-thirds. The Crop Science Division at Bayer employs a total of 7,100 scientists in its 20 R&D centers worldwide. The company invests more here in the search for innovations than any other in the industry: The research budget in 2020 was around €2.0 billion. The task here for researchers is to create the conditions for a sufficient food supply while also facilitating the most efficient and responsible use of limited resources.

#### Using resources responsibly

This includes ensuring wherever possible that food is not wasted: Every year, 1.3 billion tons – enough to feed three billion people – ends up in the trash or is wasted. In wealthy regions like North America and Europe, this is mainly due to consumers throwing away more than is necessary. In poorer regions, especially in Africa and Latin America, food most often spoils during production and storage.

Around 30 percent of the world’s population is now employed in farming worldwide – a total of over one billion people. In the world’s industrialized regions, the growing use of machinery and technology is diminishing the importance of the sector both as an employer and in terms of its share of the overall economy. The size of farm operations is changing accordingly: Farms in North and Central America are up to 120 times the size of those in Asia and 60 times larger than farms in Africa. But farming contributes significantly to economic output and the respective gross domestic product in the developing and emerging countries of this region – it makes up over 20 percent in Nigeria, for example. Small farmers in particular bear a special responsibility in these countries: Their work covers around 80 percent of local food needs.

#### Support for 100 million small farmers

Bayer has therefore placed a special emphasis on smallholders as part of its sustainability strategy, which is particularly focused on reducing the company’s own carbon footprint as well as the negative environmental impact of agriculture and crop protection as a whole: By 2030 the Group will be helping 100 million small farmers in developing regions by improving their access to agricultural know-how, products and services, as well as to partnerships.



As one of the world's best-known trademarks, the Bayer cross symbolizes the Bayer Group, which was founded more than 150 years ago. It stands in particular for the innovative spirit that also characterizes the Monheim site as the largest research center and headquarters of the Crop Science Division at Bayer.

### Comprehensive range of customized products and solutions

The supply of very specific products and solutions Crop Science develops and provides for farmers worldwide ranges from traditional crop protection products that combat weeds, diseases, harmful insects and fungal infestations, to seeds and plant traits, and to innovations in the field of digital agriculture.

Everything at the location in Monheim am Rhein revolves around crop protection: The researchers here are focused on the plant as soon as it grows above the earth's surface. They are increasingly using data science in their efforts, in addition to their biological, chemical and biochemical expertise. This facilitates and speeds the process of identifying, testing and selecting molecules with the best possible toxicological profile. This means that the effect of the crop protection product is entirely focused on the target organism and that the product has no harmful impact on nontarget organisms or on the environment. Today's crop protection products from Bayer provide farmers with effective and sustainable tools they can use in an increasingly targeted and economical manner. This enables them to achieve adequate harvests while also consuming fewer natural resources. ►



**NO. 1**  
market leader in all  
important market  
segments (corn, soybeans,  
vegetables and horticulture)



**€18.8  
billion**  
*in Sales  
in 2020*





About  
**33,000**  
employees  
from  
**88 countries**  
worldwide

Crop Science is ...

## // DIVERSE

*From more than 40 nations:  
2,000 researchers from  
various disciplines work  
together with business  
managers to shape the  
future of farming at Bayer's  
Monheim campus.*

Seeds and plant traits are the result of biotechnological research and development, which is concentrated in particular at the location in St. Louis, MO, in the United States. The focus here is on optimizing the genetic profile of plants to make them more resistant to insects and weeds, or to growing environmental factors like drought. Scientists are studying the plants' genetics to determine what makes them more tolerant to all forms of stress. They breed crops with improved traits such as tastier tomatoes, stronger cotton fibers or even healthier rice. Or, for example, they transfer certain plant traits – like the ability to defend against pests or more efficient use of water – to a new plant so it can better cope with its environment. Biotechnology makes farming more productive and increases its yields – this is undeniable in view of a growing world population and shrinking farmable land.

### **Agribusiness advancing digitally**

Modern farming is inconceivable today without the use of digital technologies. The economic benefits of digitization for the entire sector are considerable: In 2017 McKinsey estimated its value will amount to up to US\$ 330 billion by 2025. Even small solutions add to this to an extent that shouldn't be underestimated: The use of suitable apps on smartphones or tablets alone can reduce weather-related crop damage by 25 percent. Vast amounts of new data are being generated with help from data science from information such as the seeds, fertilizers and pesticides being used as well as the crop yield, helping farmers quickly make the right decisions in the field.

Sensors, satellites and drones monitor plant health, soil conditions, temperature, nitrogen utilization and much more. All these data are analyzed at high speed and translated into useful insights or recommendations. This will make farms even more efficient in the future by allowing each parcel of land to be closely monitored and individually managed according to specific needs.

### **Proactively seeking transparent dialogue**

Long gone are the days when Bayer would communicate its commitment to greater sustainability and safety in farming merely with a green linden leaf. Since the location in Monheim was established 40 years ago, Bayer has increasingly sought dialogue with the public and has set totally new standards for transparency and openness for the industry as a whole. This is largely accomplished on the company's own initiative, but it is also meant to underscore that Bayer takes the concerns and information requirements of critical consumers seriously and is willing to provide answers to their questions. ◀



# 3 QUESTIONS FOR

## Liam Condon

Member of the Board of Management of Bayer AG and Head of the Crop Science Division at Bayer

### ACHIEVING MORE WITH LESS

*How is farming changing – also thanks to Bayer?*

In the past, it seemed that greater yield could only come at the cost of less sustainability. Thanks to science and innovation, for the first time in history we can balance productivity with protecting the environment: The aim is to produce enough food for the world's growing population – while also using fewer resources and emitting less greenhouse gas. As a consequence, agriculture is evolving with respect to climate change from being part of the problem, which it undoubtedly continues to be today, to being part of the solution.

*Do you see Bayer as more of a lone warrior – or as a team player?*

No country, institution or industry can on its own solve the complex global challenges in environment and food supply. We need more openness to science, more partnerships and transparency, and an open dialogue with scientists, farmers, politicians, consumers, and organizations that represent various points of view. Only by working together we can harness the power of science and innovation for a more resilient and sustainable food system.

*Parts of the public are skeptical of market leader Bayer. How do you deal with that?*

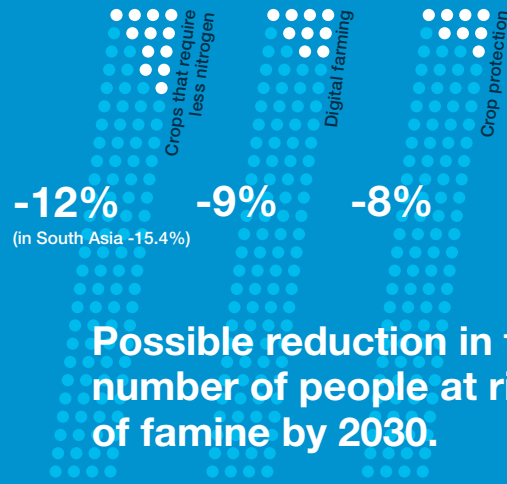
Multiple fears are usually joined together here: First, there is the fear that a large company will become even larger. Second, that farmers will be made dependent. And third, there's is the fear that innovation will come at the expense of people, animals and the environment, in order to make profits. As Bayer, we need to explain what we do much more thoroughly and, above all, why and how we are doing it. We have long focused on the farmer and have not done enough to explain to the consumer why we in agriculture need innovation more urgently than ever. We have to try harder than we have up to now to establish a dialogue.



# Where the *standards* are set

*At the headquarters of the  
world's largest agricultural company,  
we are shaping the future of  
agriculture through innovation – sustainably,  
safely and transparently.*

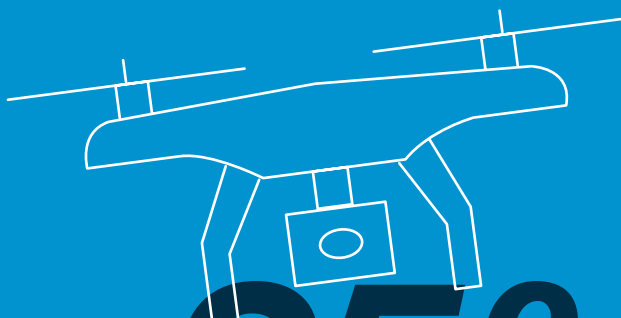




... The graphic shows the potential reduction in the number of people threatened by famine by 2030 through the use of innovative seeds, crop protection measures and modern farming technology.

“TOGETHER,  
OUR CHEMISTS,  
BIOLOGISTS,  
BIOCHEMISTS,  
LAB TECHNICIANS,  
IT SPECIALISTS AND  
AGRONOMISTS ARE  
THE **KEY** TO  
CREATIVITY AND  
INNOVATION.”

DR. BOB REITER,  
Head of Research & Development



**25%**

**Increase in yields that  
can be achieved with  
digital farming.**



*Strong*  
**together**



*As the Head of R&D for the Crop Science Division at Bayer and the boss of some 7,100 scientists worldwide, Dr. Bob Reiter is responsible for innovative farming solutions for a healthy food supply for a growing world population. He offers insights in this interview into his daily work routines, into his image of the campus in Monheim, and into the future of farming.*

***Dr. Reiter, how would you describe the Monheim campus?***

It's always a special situation when the headquarters of a company or division is also the center of its research activities. Monheim is our main location for everything related to crop protection, especially insecticides and fungicides, and it is an important site for regulatory tasks – including environmental and human safety.

***What makes Monheim different from other R&D locations?***

While most of our other research sites are very clearly focused on research activities like plant breeding, comprehensive testing of crop protection products or biotechnology, Monheim covers a broad and diverse range of functions. If you listen to what's being said around the cafeteria, you might hear a discussion about strategy at one table. At another, people are talking shop about an upcoming product launch. Beside them they are talking about a recent meeting with customers, while at the next table the conversation is about regulatory challenges, and so on. This diversity characterizes the atmosphere of the campus. Added to this is another unique feature of this place that is often underappreciated: Unlike in St. Louis, Frankfurt ►

*The fact that the campus in Monheim is completely surrounded by farmland connects this place to its purpose and gives it an important emotional quality, says Head of R&D Dr. Bob Reiter.*

er



or Lyon, for example, where we are located in the middle of an urban or commercial setting, our campus in Monheim is completely surrounded by farmland. This connects the place to its mission and gives it an important emotional quality.

***Do you remember your first visit to Monheim?***

***And how do you experience the location today?***

I got my first impression before I even arrived at the campus. I noticed a traffic sign pointing the way to the location – I thought that was notable at the time because I was from a world where people didn't advertise where they worked. Today I share the self-confidence with which Bayer presents itself here, and the large Bayer cross in the entrance area makes me proud to be part of this company. I experience the campus as a whole – with its Japanese-style architecture and its variety of shapes and colors, the wide green spaces and greenhouses – as a special place. And the Tropicarium, which brings a bit of the rainforest to the Rhine, so to speak, is a sensation in itself for the employees as well as visitors.

***But Monheim is just one location and is a part of a global R&D network. What role does the campus play and how do you manage a global network today?***

We have almost 200 research and development laboratories worldwide, as well as breeding stations of various sizes and in different time zones. So we all have to work together as an integrated team while also harnessing our diversity. This can be very challenging – and very rewarding.

Even though Monheim is one of the most important hubs for the Crop Science Division at Bayer, we don't want to be a command center here. We see ourselves as part of a network or ecosystem. Each unit makes its own special contribution within this, so that the mixture works as a whole. Collectively, we have an incredible range of expertise, skills and talents: The collaboration of geneticists, chemists, biologists, biochemists, IT specialists, agronomists and laboratory technicians is key to creativity and innovation – across all locations. I like to compare our product range for farmers to a full toolbox that contains and integrates all these highly diverse tools – with no trace of silo thinking. This is what makes us so successful.

***How does that work in practice?***

In my opinion, the biggest breakthroughs succeed where there are interfaces – between the digital world and science, for example. The same thing applies to talent: If you want to benefit from as many perspectives and ideas as possible,



***“We have an incredible range of expertise, skills and talents in Monheim.”***

Dr. Bob Reiter

you have to give the people involved the opportunity to contribute themselves and their expertise. Valuing different ways of thinking is the key to fully exploiting our potential. I am also a big believer in inclusion and equality as an underpinning of society and business. The percentage of women needs to be increased, for example, even if it is already 50 percent in some areas. And that in turn pays off when it comes to our corporate objective: Bayer is striving for gender parity at all levels of management and



*The research head emphasizes that Bayer is constantly working to further reduce the footprint of farming in order to protect things like biodiversity.*

#### DR. BOB REITER

As Head of **Research & Development (R&D)**, Dr. Robert (Bob) Reiter is also a member of the executive management team of the Crop Science Division at Bayer. Over the course of his career, Reiter has held various leadership roles in this area as well as in supply chain management. The native-born Canadian has almost 30 years of experience in discovering, developing and delivering innovative R&D solutions in the agriculture sector. Reiter holds a master of science and doctorate in plant breeding and plant genetics from the University of Wisconsin-Madison as well as a bachelor of science in horticulture from Pennsylvania State University.

is intensifying its efforts to create an even more inclusive and diverse workforce and corporate culture.

***How is Bayer responding to the major challenges posed by population growth, climate change and the decline in biodiversity?***

There are many answers to this question. In short, we have been helping farmers produce an abundance of food for many years. Today the focus is on enabling greater yields per hectare in order to continue being able

to supply food to a growing world population in the future as well. Demand for the next 30 years will be roughly the same as that of the past 10,000 years – we have to keep that in mind. At the same time, we also need to address the environmental impact of farming. We are constantly working to keep the footprint of agriculture as small as possible – to protect biodiversity, for example. This includes not only using fewer chemicals but also offering products that are constantly being made safer. In this context, ►

we are countering the issue of residues of our active ingredients by bringing products to market that leave either very little residue or none at all.

And lastly, we are focusing our attention on how farmers use our products. We are ensuring that data is collected and analyzed so that crop protection products are only used in the field precisely where and when it makes sense.

We also need to help address the challenge of the carbon footprint as well, of course. We want to reduce our own emissions of carbon-containing greenhouse gases, but we also want to support farmers in working in a more carbon-friendly way. And we are just getting started on that journey.

## ***In what direction is farming headed, generally speaking?***

The task for farming is to ensure a secure, abundant and cost-effective food supply. That won't change. But we need to improve efficiency and resilience. Even though almost everyone now agrees that we must stop climate change, its impact on the environment has long been a reality. So we need solutions in the field that can better cope with dynamic environmental conditions like heat, drought and severe weather.

## ***What impact does this have on the R&D activities of the Crop Science Division at Bayer?***

As a global leader in the agricultural sector, we provide farmers with the best crop protection products, seeds and plant traits. But it won't be sufficient long term to simply produce the next great molecule, and our work is not finished once the seed bag has been produced or the formula of the crop protection product has been completed. We must develop an understanding of the factors that lead farmers to have success with our products so that we can guide them to use those products as efficiently as possible.

To do that we have to find out in detail how our products interact with the environment in everyday use. After all, no two square meters of a field are alike. Today's harvesting machines are equipped with yield monitoring systems that record yield results in real time as the combine harvester moves across the field. If you watch this process, you

**“We have a lot of fertile ground ahead of us – ground we must cultivate if we want to harvest the fruits of our integration.”**

Dr. Bob Reiter



*Dr. Reiter would like to see the portfolio renew itself more quickly than it has up to now, since even a product that is “only” five years old deprives farmers of part of their yield.*

quickly notice that some parts of the field yield twice or even three times as much as others do.

There is an enormous opportunity here for delivering improvement and consistency: We can simultaneously achieve additional yield and optimize the use of crop protection products. This is an extremely data-intensive area, and it presents a challenge in our research. We need to shift our own capacities toward data science and establish the right mindset in the organization.



***Should we expect to see new plants and plant traits or new crop protection products every year in the future? Or is the focus more on highly developed life cycle management for established products?***

The innovation cycle isn't becoming slower because we are making more sophisticated products. Both of these things are happening in parallel. We have to do a better job of harnessing our value creation options after launching products by collecting more data and by using it more effectively. And we also need to increase our innovation rate. After a few adjustments, our chemical crop protection portfolio currently comprises around 65 active ingredients. If we continue at our current rate and launch just over one new active ingredient per year, it would take more than 50 years to renew our portfolio – that's a very long time, and this is where I would like to see the pace accelerate.

***Artificial intelligence is a part of digitization – what role does it play at Crop Science and for R&D in particular?***

Artificial intelligence enables us to make better decisions. We already have the first tools for improving the efficiency and the success rate of our research activities in this regard. This is another area where we are still at the beginning of the journey, but we have a lot of fertile ground ahead of us – ground we must cultivate if we want to harvest the fruits of our integration.

***What's your vision for the agriculture sector ten and 20 years from now?***

In ten years, digital processes will shape day-to-day work in agriculture. Farmers will especially benefit from automation: Drones and self-driving equipment will work the fields. Safety and our commitment to regulatory processes will continue to be some of our top priorities, but these will also evolve accordingly and influence our products. We will then have pesticides with completely new modes of action, and will make greater use of biological products. Farmers will be able to make optimized decisions tailored for each square meter on the basis of very precise data, thereby tapping into enormous, previously unutilized productivity potential.

In 20 years we will be much closer to having an answer to the question of what kinds of foods we want to consume. The consumption of meat – or of protein in general – will change the nature of agriculture.

We're likely to have crops that are specifically designed for downstream use and processing, such as soybeans for meat production or soybeans for direct consumption in plant-based foods. Because it is becoming increasingly difficult to find labor, especially for small farmers, agriculture is continuing to move away from manual tasks – not only in Asia but also in Africa in particular, where I expect agriculture will be much more autonomous and mature in 20 years than it is today. But there will still be farmers – and we will still need them. ◀

Crop Science is ...

## // INNOVATIVE

*Biology, biotechnology and crop protection: With world-class research and digital technology, Bayer is developing highly effective yet safe solutions – faster than ever before.*

# 20,000 citations



*Trained eye: Entomologist Dr. Ralf Nauen examines a cotton plant infested with aphids.*



*Having started at Bayer almost 40 years ago, Ralf Nauen can safely be called a true “Crop Science veteran.” With his experience and standing as a scientist, in Monheim he represents the comprehensive crop protection expertise that Bayer is known for.*

Whether he's on the tennis court with his wife or working at the office, there's no real difference for Dr. Ralf Nauen when it comes to having fun: “My job is also my hobby,” the 56-year-old assures us convincingly. His job at Bayer in Monheim is, among other things, to research why harmful insects develop **▶ resistance** to crop protection products and **▶ transgenic** plants, and to develop solutions to prevent or delay these things from happening. And the **▶ entomologist** does this with so much passion that he doesn't consider even a 70-hour workweek to be a burden. His secret: “Passion is important – finding a profession that excites you. And you can't let yourself get burned out. This definitely includes sometimes deliberately breaking the rules,” Dr. Nauen says. “But perhaps not where the greatest consequences might threaten.” As a researcher, he has often secretly continued working in areas where superiors thought an issue was less interesting and should therefore be ignored. “That has paid off in many cases,” he states. “Opportunities have repeatedly resulted from that.” Dr. Nauen takes advantage of the freedom to design his scientific work in other ways as well. Pressure should not be allowed to build up – he has always ignored that anyway.

His consistent mindset has paid off: Today, the biologist who holds a doctorate in the discipline is considered one of the giants in his field and he is highly regarded far beyond the confines of Bayer. Both the Royal Entomological Society of London and the Entomological Society of America have named Dr. Ralf Nauen a fellow, or elected member, an honor that has so far been bestowed on only three of his colleagues. He was recognized in 2014 with the International Award for Research in Agrochemicals from the American Chemical Society, one of the world's largest scientific societies. As the author of more than 200 scientific publications, Dr. Nauen has been cited some 20,000 times to date.

#### **High-profile recognition**

Although the devoted scientist doesn't like to shout about his successes publicly, he is aware that recognition of his

work also enhances the reputation of his employer and provides practical benefits for the company: “Bayer enjoys an excellent reputation, especially in resistance research. We now have a global network of external scientists with whom we maintain incredibly open and friendly relationships. We are often contacted by universities that want to work with us as an equal partner.”

His remarkable career began in 1981 when he trained as a biology lab technician at Bayer. Even as a child, he had been passionate about insects, hunting bugs and collecting butterflies. So it was not surprising when, after he arrived at the Crop Protection Center in Monheim, he became interested in insect toxicology and biochemistry. Inspired by the graduate students with whom he had worked in this field, he resumed his education accordingly and eventually earned a PhD in biology from the University of Portsmouth (England). ▶

Crop Science is ...

## // EXPERIENCE

*For more than 110 years, our scientists have been extremely successful in researching how to protect a wide variety of crops from diseases, pests and weeds.*



*Fighting pests as a team: Dr. Ralf Nauen (center) researches new strategies with Marion von Zeddelmann, Viola Müller, Julian Haas, Bettina Lueke, Harald Köhler, Melanie Nolden, Sonja Mehlhorn and Lea Celine Haack (from left).*

One of his first official acts as a resistance researcher at Bayer was to publish study results in 1994 that suggested the whitefly had developed resistance to Bayer's insecticide imidacloprid. This was a serious setback because it meant that an important sucking pest and virus vector – one that causes significant damage and crop losses in a wide range of crops – could no longer be controlled with one of Bayer's blockbuster products. "I was summoned with my boss at the time to the head of Marketing, who suggested that I retract the 'discrediting' publication. After all – as he asserted – there was no resistance to Bayer insecticides. It caused serious trouble," Dr. Nauen recalls. But three months later, that same man thanked Nauen for the fact that Bayer researchers were the first to point out the problem. "For the maker of a crop protection product to itself publish something unflattering about its product was a real first at the time and caused a minor sensation. It took a moment, but then people also saw the positive effect it had on our company's credibility, which is essential, especially for our collaboration with academic researchers."

### Modern, selective substances

Dr. Nauen has long been primarily concerned with the mechanisms of action of chemical crop protection products. Since the beginning of his career, when **organophosphates** from the 1950s were still popular, both insecticides and the regulatory conditions have changed enormously: "In contrast to the old active ingredients, which were certainly not entirely ecotoxicologically harmless from today's perspective, modern substances like our new butenolide Sivanto® are very selective tools that only work on specific target organisms – and mostly spare other insects," the resistance expert explained. Even so, Dr. Nauen also admits that species diversity is declining – something he's noticed from the insect hotels he built himself in his own garden. The phenomenon must be studied, but with a sense of proportion and taking into account the many other underlying conditions that are negatively impacting **biodiversity**.

Conversely, crop protection products can ensure that diseases are driven out of agriculture: For 30 years, for example, mild yellowing virus was not a problem for sugar beet cultivation – until now.



For the past two years, seeds may no longer be treated with the **neonicotinoids** that protect the plant from the aphids that transmit the virus. More and more desperate sugar producers have been calling Dr. Nauen to share their serious concerns about crop losses. “There is currently no alternative we can use to combat the pest,” the entomologist explains. “They have evolved metabolic resistance by revving up their metabolism and digesting certain insecticides in a very short time – much the way some humans can metabolize a medicine faster than it can have its desired effect.”

### Bee toxicogenomics

Today, Dr. Nauen also handles health projects for pollinators such as honeybees. “Working as a team with my co-workers, graduate students, and postdocs, we are looking at the genome level for determinants we can use to predict selectivity. In other words, can genetic fingerprinting tell us whether bees will tolerate an insecticide?” Dr. Nauen says. “With a new technique we call ‘bee toxicogenomics,’ we are determining at the molecular level in pollinators not only whether the animals are tolerant, but why.”

The integration of Monsanto has also bestowed Dr. Nauen with some additional tasks: “We are handling resistance research on harmful insects with resistance to transgenic plants for our colleagues in St. Louis.” The **armyworm**, for example, has spread almost worldwide from its origins in Brazil. The caterpillars of this extremely destructive pest have developed resistance to an insecticidal protein used in transgenic corn. The increased use of sprayed insecticide that this is requiring runs counter to efforts to use fewer chemicals in the fields. These are not available in many countries, however, due to lacking registration. This has led to a massive threat to crops in Australia, for example – and up to 17.7 million tons of corn are lost each year worldwide, according to estimates by the **FAO**.

Faced with such challenges, Dr. Ralf Nauen is not likely to get bored in his job. And aside from all that, someone who sees teaching at the Bonn Unit and writing technical articles as an exciting hobby, as he does, doesn’t experience much stress – or, at least, doesn’t hide from it. ◀

## GLOSSARY

### › Biodiversity

Wide variety among living organisms, specifically including ecosystem diversity and diversity within and between species.

### › Entomology

The study of insects. It is concerned with the most diverse group of living organisms. With nearly one million species described to date (20,000 of which are bees alone), insects account for about 60 percent of all animal species.

### › FAO

Food and Agriculture Organization of the United Nations. It is concerned with the production and distribution of agricultural products worldwide to ensure food security.

### › Armyworm

*Spodoptera frugiperda* – a species of butterfly that originated in South America and has now spread worldwide, whose caterpillars first and foremost infest corn and severely damage crops.

### › Neonicotinoids

Highly effective, selective insecticides most commonly used as seed treatments (e.g., cotton, corn, sugar beets, canola) due to their systemic effects.

### › Organophosphates

Most extensive and diverse group of active ingredients against insects and mites – includes Baythion (insecticide introduced by Bayer in 1968, no longer approved in the EU since 2007).

### › Resistance

Process of selection through mutation on the gene of an insect where an insecticide is effective. The insecticide can then no longer bind and the insect survives. A resistance allele forms.

### › Transgenic plants

Implanting certain genes from other organisms into, for example, the corn genome, improves the ability to combat harmful insects and reduces the need for pesticide use.

*The whitefly is an important sucking pest and virus vector in many crops.*



*The armyworm caterpillar has developed resistance to transgenic corn.*

*The varroa mite is considered the most significant bee parasite in the world.*



*The pipetting robot is one of many examples of high-tech automation in the laboratory.*

# Strategic from the *start*

*The development of new products and solutions for agriculture is much like a marathon – during which most of the runners fall by the wayside. This makes it all the more important to create the best possible conditions right from the beginning.*

When the search for a new crop protection product begins in Monheim, it takes an average of ten years – if it ever happens at all – for the product to be sold for the first time and used by farmers in the field. Before a single finished product makes it into a bottle with the Bayer cross, tens of thousands of candidates are often discarded during the long journey. This can happen because they are not effective enough, or because they have undesirable side effects on beneficial insects like bees, or because they break down in the soil too slowly – or too quickly. The list of possible reasons a chemical substance is not pursued in product development is long.

Given the pace at which the world is changing – and farming along with it – ten years is a long time. How is it possible to plan for the long term and develop market-relevant crop protection products whose life cycle only begins ten years after the initial idea? How can the needs of both society and agriculture be anticipated so far in advance? “Defining our strategic research targets is in fact very much a forward-looking job,” says Dr. Rolf C. Becker, who is responsible for plant diseases in fruits and vegetables in the Crop Technology Team Food Crops at Bayer. “We look at the relevant crops and think about what challenges could develop over the next decade. In addition to the question of new pests and new diseases, megatrends like climate change are also very important.” Resistance is also a big issue: Current active ingredients become less effective over time or lose their effectiveness altogether. Pests and plants are developing resistance at an ever faster rate. The to-do lists for researchers therefore always include new modes of action. And that’s always the biggest challenge: inventing something completely new that has never existed in this form.

In the Crop Science Division of Bayer, long-term research targets are set every four to five years; priorities are reviewed annually and reassessed where needed. The

team responsible for this, which includes Dr. Becker, is made up of people representing a wide variety of areas: Strategic marketing incorporates customer perspectives and demands, for example. The researchers, on the other hand, assess the probability of success of the targets being discussed, while colleagues from development contribute what new rules for the approval of crop protection products are to be expected in the different regions and countries. “Our perspective is always a global one,” Dr. Becker emphasizes. “On the one hand, we as Bayer live up to our responsibility to contribute to a sufficient food supply. And on the other hand, we rely on global markets to justify the huge investments tied to our research activities.” Considering the growing social consciousness, environmental behavior also plays an enormous role, even at this early stage. Dr. Becker is impressed by the ►

**“We are thinking about what challenges might develop in the relevant crops over the next ten years.”**



**Dr. Rolf C. Becker,**  
Technology Team Food Crops





*State-of-the-art equipment ensures fast and efficient progress in research.*

level of safety that is not only strived for but also achieved today. In addition to the control of harmful insects, aspects like the protection of bees and other pollinators in flowering crops is not first considered during the course of development but is in fact defined as a research target from the outset.

The strategic work being done in Monheim primarily focuses on biotechnological innovations for corn, soy and cotton cultivation, strategic and on chemical plant protection products that enable all major crops including fruit and vegetables, soybeans, rice and cereals to withstand emerging threats. For example, what consequences will the incipient spread of the stink bug have on fruit crops in Europe? What solutions can be provided to farmers affected by soybean rust? How do you combat a bacterium that is killing olive trees in Italy? What answers can Bayer, as a research-based company, find to viral diseases in vegetable cultivation?

But the focus also extends beyond chemical crop protection: For example, which biological products are

suitable for the sensitive European market? And which partners or start-ups does Bayer want to cooperate with in this context, within a framework of open innovation models? How can the company use digital solutions and monitoring systems to help farmers growing fruit and vegetables with one of their biggest challenges: acquiring labor?

Sometimes the responsibility as a life science company extends beyond the boundaries of agriculture: How can we prevent massive economic and social upheaval in countries that are economically dependent on banana production by controlling a new fungal disease? Bayer is initiating global alliances here and contributing its research and development expertise, with the result being not just a product but often a tailored solution comprising specific measures.

## From goal to product

But how does a strategic goal become a concrete product? Where do the new "hits" originate? "It's ultimately a bit like a relay race where we are the starting runners who start off at the very front," explains Dr. Jürgen Benting, Head of Early Discovery Pest Control at Bayer, summarizing the process: "Research and development essentially happens in three phases: In the early research phase, an effective new chemical structure is first identified and then modified repeatedly until a new and better molecule meets the requirements. The early pipeline phase then studies whether a product also works in practice and whether it meets current safety requirements and can therefore be approved. The formal development decision is made in year six of ten, which is the average time the process takes to the product launch. Starting from this point, all steps required for formal registration by the competent authorities are implemented."

Phase one in Monheim is based on two complementary research approaches: First, in vivo screening of new molecules on the most important target organisms – that is, directly on insects – and second, target-based in vitro screening. Here, only one protein from an insect is used at a time in order to selectively find molecules from Crop Science's own compound library (see "Treasure trove" box) that bind to this target protein.

## In vivo screening

Of the 40,000 new chemicals tested in the laboratory each year on insects like mosquito larvae or lice, a few hundred to a thousand molecules are noted to be biologically active. This first screening stage, during which model organisms and artificial laboratory tests like mosquito larvae in liquid



are still used, is followed by further stages that replicate increasingly complex requirements and come ever closer to real-world conditions. These include use on harmful organisms like aphids, spider mites, beetles, caterpillars or bedbugs, right through to trials in greenhouses. Once a new active compound has been found during screening, initial analyses of the mechanisms of action are performed immediately, and researchers gain information about undesired toxic properties in nontarget organisms. "Our goal is to find new molecules with new modes of action and to optimize these initially weakly active compounds so that we can test them in the field," says Dr. Benting. "We have been using our screening methods for more than 20 years. During this time, we have gained an enormous amount of expertise. With the quantities of substances we test in order to deliver real innovations for farming, we are truly a world leader. This is also true when it comes to the number of patent applications Bayer has filed."

In the early-stage research, there are usually ten to 15 projects being worked on in parallel. Of these, one or two will be handed off to the next phase each year. "We are continuously picking up new loose ends," Dr. Benting explains. "The chemists on the team design 20, 30 or even several hundred related structures around a new "hit" structure, and our biologists and biochemists closely examine whether their effectiveness is better or worse. We use this method to study the relationship between structure and effect, and to learn which parts of an active ingredient contribute to the effect and where there is still room for improvement. If the effect cannot be increased – and this often happens, unfortunately – we put the subject aside. So it's naturally all the more exciting when our carefully designed molecules keep getting better and we can hand them over to the next phase of research."

#### Target-based screening

The second research approach – target-based screening – focuses on molecular targets. "The fruit fly, for example, has about 14,000 genes," Dr. Benting says. "We know that from 30 to 40 of these are molecular targets – which leaves many more we can study. In addition to harmful insects, we are also looking at bees and other beneficial insects that we want to conserve. Our search for new targets is therefore not focused on just one organism, as is the case in medicine, but instead includes the genes of around 100 different organisms. Bioinformaticians and data scientists help us identify the right molecular targets here."

Once Bayer researchers have understood how a fungus functions in a plant, for example, and how its metabolism might be disrupted, biochemists enter the picture. They bring together active ingredients from the compound library with the corresponding proteins, also known as targets, and measure which ones work. The result of this in vitro screening is a list of "hits" with the most valuable molecules, which serves as the basis for the further phases.

"You'll have to look long and hard in crop protection to find an in vitro laboratory that compares to Bayer in terms of efficiency," Dr. Swantje Behnken says with pride. ►

***"With the quantities of substances we test in order to deliver real innovations for farming, Bayer is truly a world leader."***



**Dr. Jürgen Benting,**  
Head of Early Discovery Pest Control

***"You'll have to look long and hard in crop protection to find an in vitro laboratory that compares to Bayer in terms of size and efficiency."***



**Dr. Swantje Behnken,**  
Head of Target Biology

The biochemist is Head of Target Biology, which screens up to 300,000 substances a day, and is impressed by “the progressive spirit in today’s agrochemistry.” High-throughput screening places tough demands not only on automation, test procedures and analysis, but also on flexibility: “We are confronted with various indications and have to replicate various systems, depending on whether we are looking at insect, fungal or weed targets,” explains Dr. Behnken. “So the requirements for the type of evidence also vary. For pest control, for example, we performed the world’s first optogenetic screen in the agricultural sector, where we measured electrical pulses in a model system of insect neurons.”

Today it is important to have methods that have very sensitive methodology and that are effective with the lowest concentrations. “We’re not looking for ‘brute force’ substances, but rather for selective modulators of systems that can be targeted. For this we need a methodology that allows us to perceive even the slightest differences.” Efficacy and safety are equally important goals. Managing risk is an essential part of research today, from the very start. ◀

Crop Science is ...

## // DISRUPTIVE

*The Crop Science Division at Bayer sees itself as a think tank that goes beyond products to develop entirely new business models for tomorrow’s agriculture, as a partner to farmers worldwide.*





## Treasure trove with a world record

With around two and a half million substances – almost 80 percent of them proprietary Bayer molecules – the Crop Science Compound Library at the Crop Science Division at Bayer represents the world's largest collection of active ingredients for the agricultural sector. Thus it is a treasure of inestimable value. With it, biological research has a full arsenal of substances at its disposal for identifying the starting point for a new product – an immense time advantage on the long road to a new crop protection product. Within a few months, several thousand “hits” can be obtained which form the basis for further screening.

This is made possible thanks to a high degree of automation: Four picking robots complete around 2,000 orders daily, storing and retrieving the bottles, taking samples, weighing them, dissolving the substances and placing them via pipetting machines into microtiter plates. Continuous miniaturization and high-tech equipment enables consumption of the precious chemicals to be made more and more efficiently: While about 50 tons of glass vials weigh down the shelves, their contents currently only amounts to a round about 700 kilograms, according to the estimate of Dr. Mark Drewes who oversees the library as Head of Research Logistics. When asked about the value of their contents, he estimates: “If we calculate ten euros per milligram of material, that comes to around 700 million euros – a fictitious amount, since most of it is not freely available for purchase.” The safety precautions are correspondingly

extensive, including a high-pressure water-mist extinguishing system as well as an emergency power supply that ensures that all computers are shut down in time without any data loss.

The 600-square-meter library adds up to 50,000 substances each year and currently has space for four million more bottles – so there's no reason to fear we'll run out of space any time soon. And if the repertoire of the Crop Science library should ever prove inadequate, the integrated life science company Bayer still has the library from Bayer Pharmaceuticals at its disposal with around five million active ingredients.

***“The use of cryocondensation at this small scale is fascinating – and something completely new.”***



**Dr. Mark Drewes,**  
Head of Research Logistics



# Knowledge



# is power

*Extracting knowledge from data is one of the key disciplines of digital transformation. And it can be even more exciting when this knowledge streamlines the development of new products, as two data scientists from the Crop Science Division at Bayer explain.*



# edge

Listening to Dr. Fuad Abdallah can make your head spin. The bioinformatics expert talks about 50- to 200-dimensional models, vector and graphics structures, linear transformation, deep learning, point clouds, and target profiles at such a speed and as such a matter of course that it might be difficult to follow what he's saying – or it would be, if the bottom line of his message weren't so simple and clear: Using data science methods in the development of active ingredients improves the likelihood of success in the search for new substances, and it reduces the development time required before the product is ready for market.

### Inspiration for chemists

The details of this process are highly complex and practically impossible for laypeople to understand. The profiles of existing substances are correlated with target profiles, and certain desirable product traits and dimensions of a new ingredient – such

as shelf life, solubility, duration of biodegradability, non-harmfulness to nontarget organisms – are translated into mathematical characters and models. The system learns from many examples by searching in the proximity of existing structures. This creates models which, in turn, can generate new structures – all without a single laboratory experiment. The result is molecules for substances that can serve as a source of inspiration for the chemists.

The process sounds complicated, but it delivers concrete results: “Many of our proposals have already been synthesized in the lab,” says Dr. Abdallah happily. “Initial test results have shown that we can even predict complex biological properties, such as effectiveness in various organisms. We are also testing the next series of substances and have already produced our first papers.” The key to their success was an excellent interdisciplinary team made up of two mathematicians, a computer scientist, and chemists, one of whom has an extensive background in machine learning.

“We always have more and more data coming in,” Dr. Abdallah says. “No one could ever manage to review the results of 200,000 experiments or more. At the same time, the ability to translate this data into products is becoming increasingly important for maintaining our competitive edge on the market.” That's why the bioinformatics expert approves of Bayer's strong strategic focus on data science. After all, his department is currently being expanded into an expert team of 40 – and they will be held to very high standards.

“We cooperate with researchers at the Massachusetts Institute of Technology (MIT), one of the world's leading think tanks,” explains Dr. Abdallah. “For example, we can use their tools to compare the content and functions of our processes.” Naturally, the fact that Bayer is a renowned company, rich in academic resources, opens doors. However, the quality of the content is what counts: “The results of our work are on a comparable level to MIT's,” Dr. Abdallah notes, and jokes: “We were really reassured to learn that we aren't the only ones ►



*Bioinformatics expert Dr. Fuad Abdallah works with the world's top data scientists on an equal footing.*



Using artificial intelligence to develop innovative formulations: mathematician **Dr. Kathrin Hatz**.

who think we're great!" There's no question about it: The work being done in Monheim is of the highest international standard. Dr. Abdallah highlights Bayer's unique selling point: It is the world's only company that is involved in both human medicine and phytomedicine – working to improve both people's health and the health of plants. "The close communication between the Health Care and Crop Science Divisions at Bayer allows us to learn from each other very quickly. We use similar methods, and we inspire each other. For example, we developed a tool for machine learning experts, and the Pharmaceuticals Division developed one for chemists. We then sit down and examine these tools together and discuss how we can adapt and make use of the other's work for our own purposes. The positive interaction during this process is a real competitive advantage."

## Mathematics with added value

Dr. Kathrin Hatz isn't a chemist or a

biologist; she's a mathematician, who – as she puts it – is looking for ways to apply her expertise that will make a difference within the company. In the past, for example, she has focused on dosage predictions for clinical studies of new medications or modeling the effectiveness of chemicals in the human body. She has worked in Monheim for three years. The spirit of optimism among the rapidly growing circle of data scientists in Crop Science is what she finds most exciting. Today, Dr. Hatz heads up a team that specializes in formulation and is succeeding in generating added value from data.

Formulation is what turns a substance into a crop protection product that can actually be used in real-world agriculture. "While the active ingredient on its own could degrade or never reach the part of the plant where it's needed, the formulation ensures that the chemical structure of the ingredient makes it to the field and can penetrate the plant – and won't be washed away by rain on the surface of the leaves, for example," Dr. Hatz explains. "In

this context, the important aspects of the product include good shelf life, good applicability, and that an ingredient is packaged in such a way that it will have the desired effect on the plant. There is a great deal of chemistry and physics involved here – for example, if we want an emulsion to remain stable and not to separate."

How can data science help in this area? Dr. Hatz gives an example:

"Let's take a look at how substances break down in the soil: One of the things we look at is how an ingredient reaches the roots of a plant and stays there without byproducts getting into the groundwater. In order to design the optimum formula, which consists of a multitude of components, we need increasing numbers of measurements from earlier and earlier stages. The lab quickly reaches the limits of its capacity here. As data scientists, we analyze past results as well as processes that occur in the soil. We can translate this information into equations and display it as a model that can partially replace real measurements and also provide us with insights regarding which measurements are most significant and consequently need to be carried out." The example she mentions led directly to a 30-percent expansion in capacity and made it possible to identify solutions at a much earlier stage. The mathematician is particularly proud of the fact that their AI-based modeling system isn't an "off-the-shelf" system; it was developed by her team for their own specific applications.

Another example involves the prediction of formulations for products that are in development or are being updated. As a first step, Dr. Hatz and her colleagues developed coding that mathematically maps every conceivable aspect of the formulation: Which solvents from which manufacturers



are used at which concentration? Where is the melting point? Which emulsifiers are used? They use many thousands of historical formulations to construct a data-driven artificial intelligence model that puts all dimensions into a sequence that generates the desired properties. "So far, no one else in the industry has done that," says Dr. Hatz, pleased. "There are physical models of individual aspects such as the behavior of solvents, but our holistic approach to prediction actually is something entirely new." However, she adds, the real highlight is that their model can make its own recommendations for formulas that might improve properties such as chemical stability. These new insights came as a surprise to the formulators, she says.

### Open to other vocabulary

Integrating data science into the traditional disciplines of biology, biochemistry, and chemistry isn't without its challenges: "Particularly in the technology and analytics sectors, it is vital that data science understands what's really happening," Dr. Hatz emphasizes. This requires openness and the willingness to learn the vocabulary of the other side in each case, she explains. "Rather than just playing with data on our computers and generating the odd hypothesis now and again, we are sitting around a table with other scientists and having discussions. This type of interdisciplinary cooperation makes the job so exciting and really leverages innovation

in our products." And that's a good thing, Dr. Hatz says. After all, Bayer wants to develop innovative types of formulations that tap new markets, are extremely safe, and facilitate the use of the smallest possible amounts of active ingredients, she says. "It involves so many complex dimensions that it would be impossible for the human brain to navigate them all on its own."

In order to make major progress, we need to be bold in tackling new challenges, Dr. Hatz says: "It's typical of Bayer to give researchers enormous latitude. Nothing ventured, nothing gained – this approach is absolutely essential in data science, and it's what helps us move forward."

## The digital farm



Growing numbers of farmers are using digital technologies in their day-to-day work.

Product development isn't the only area where a paradigm shift toward digital processes is taking place; applications in agriculture itself are also increasingly reliant on high tech, data, and devices. From robots and drones to apps on farmers' smartphones, growing numbers of digital assistants help ensure precise application of crop protection products – exactly where they are needed, at the right time, in the right amount, and without pesticides ending up in places where they don't belong. Cameras and sensors iden-

tify green coloration and count aphids and weeds, while computers correlate recorded weather data and activate automated spraying processes as needed. Bayer is committed to using new technologies to help inspire a new generation to take an interest in agriculture and reverse the demographic trend in farming. Delivering the benefits of digital technology to farmers and to agriculture as a whole is yet another way in which Bayer is shaping their future.

Openness and  
transparency are  
vital for building  
trust in the Life  
Science Division.

# Building *trust*

*Do good and talk about it – this piece of advice directed at corporate communicators nearly 50 years ago is just as relevant today as it was then. A company that provides groundbreaking technology to the agricultural sector can benefit from talking openly about it to an interested public.*

In this day and age, many people are concerned about climate change and the state of the environment. They are worried about the declining biodiversity of our planet, and they are searching for the causes of phenomena such as the decreasing populations of wild bees. They take care of their health and watch what they eat. They are concerned about pesticide residue in their food and try to make their consumption habits as sustainable as possible.

They need comprehensive knowledge in order to make informed decisions. But the information about these issues presented in the press, on social media, and sometimes

by different researchers is often wildly variable and can even be contradictory. The coronavirus pandemic has demonstrated this fact all too clearly. Public discourse often becomes heated, and it is increasingly difficult for individuals to separate fact from fiction in this era of “fake news”. The result is polarization and mistrust, particularly of politicians and business, but also of science, as people believe that they are being deceived and prevented from accessing important information.

Consequently, earning trust requires openness and transparency. This holds particularly true for Bayer, which,





as a life science company, conducts research in the critical fields of health, nutrition, and agriculture. When it comes to complex, sensitive challenges such as medicine and food, trust is the basis of all relationships with stakeholders. In order to give consumers the opportunity to discover for themselves that Bayer's work meets the highest standards of scientific integrity and committed to a significant ramp-up of its measures to promote transparency a few years ago.

Since 2017, the Crop Science Division at Bayer has been providing access to its safety studies for noncommercial purposes; these studies have been submitted to regulatory authorities for registration purposes, but not shared with the public. The decision to be this transparent, which is a first in the industry, was preceded by consultations, coordination, and risk analyses that involved scientists, lawyers, data privacy specialists, communication experts, and members of executive management, among others. Measures such as watermarks and partial redactions are used to protect the company's intellectual property and the privacy of the researchers and authors involved in the studies. Study summaries can be downloaded, and complete study reports can be requested after filling out a form with a license agreement. The

platform also offers extensive material explaining the scientific studies.

No other company has taken such a far-reaching step voluntarily. The response to the initiative from within the industry and from global regulators has been positive – and increasingly, other companies are opting to follow Bayer's example.

For the Crop Science Division at Bayer, disclosing the study results submitted for crop protection registration was just the beginning. In order to continuously raise ►

## // YOUR ACCESS

*to studies,  
background  
information, and OpenLabs  
from Crop Science*



Crop Science is ...

## // TRANSPARENT

*Leading role in the agricultural industry: The Crop Science Division at Bayer is setting new standards of accessibility and transparency in its dialogue with the public.*

the bar for transparency, the company added three new pillars to its program as part of a second phase in 2020: Open-Labs, access to approval documents and background information on genetically modified crops, and background materials on plant breeding – two subjects on which the public discourse is full of myths and misunderstandings, particularly in Europe.

With the OpenLabs program, the Crop Science Division at Bayer is opening the doors to its labs, to show how rigorously its products are tested to ensure their safety, efficacy, and sustainability. In this format, interested parties can register online to shadow our scientists while they carry out a registration study. They will demonstrate what it means to adhere to OECD testing guidelines and good laboratory practice (GLP) and present the methods Bayer uses in its safety studies to produce reliable, verifiable, and reproducible results.

Genetically modified crops are vital for farmers around the world who want to make their agricultural processes more sustainable and use fewer crop protection products while coping with increasingly problematic climate conditions. These crops are just as safe for humans and the environment as nongenetically modified crops. In order to make the studies on this subject more transparent, Bayer has provided the documents submitted to the US regulatory authorities on its website. For noncommercial

purposes, full reports about safety studies on genetically modified crops can be requested from Bayer by filling out a form with a license agreement. Videos, infographics, and additional materials are also available; they help to put the science of the registration process in context, including information about how safety data is generated, and how the regulatory authorities use it to make their decisions regarding product approvals.

Innovations in plant breeding, including gene editing, make it possible for scientists to make targeted improvements in the DNA of a plant to make crops more resilient, for instance. Background information and educational materials on these subjects were also added to the transparency platform in order to improve public trust in this aspect of the Crop Science Division at Bayer's innovative work. ◀



Anyone interested has the chance to watch Bayer researchers at work.

# Positive momentum

## 3 QUESTIONS FOR Charlotte Morr and Anja Quambusch

*Is Bayer facing decreasing levels of trust everywhere in the world?*

**Morr:** Unlike in Europe, where there is a certain level of skepticism regarding Crop Science, I experienced a high level of trust in our company on my travels in other regions. However, people often question the correct application of our products and their effectiveness. In that sense, establishing trust in the overall concept is a complex task, and we need to work to earn the trust of all of our stakeholders, no matter where in the world they are.

*Who makes the most use of the transparency platform set up by Bayer's Crop Science Division at Bayer?*

**Morr:** As a first step, we made imidacloprid bee studies available, as NGOs had expressed a strong interest in them. They were followed by safety studies on other active ingredients. With the integration of Monsanto, all 107 Bayer-owned safety studies on glyphosate were made available; they had been submitted as part of the most recent approval process in the European Union. There was a quite a demand at first – particularly by journalists, investors, and researchers. NGOs requested studies, too. But within a few months, requests have really died down. It's interesting to note that the groups who had been demanding access to our studies most loudly no longer submit any requests for access now. Contrary to our initial concerns, our researchers ended up not needing to take much time to answer questions about the studies. Overall, there were a few follow-up questions and overwhelmingly positive momentum for scientific partnerships – and in that sense, the initiative really paid off.

*How do you make the OpenLabs concept accessible to people who can't come to Monheim?*

**Quambusch:** When the lockdown restrictions were in effect during the pandemic, we contacted the OpenLabs applicants whose planned visits had to be canceled, and we invited them to ask questions. We answered those questions with brief videos from experts.



**Charlotte Morr,**  
Data Transparency Manager



**Anja Quambusch,**  
Science Engagement Manager

In order to be able to offer interested parties a long-term environment for exchanging with our scientists, independently of the possibility of a personal visit, we are developing a half-day virtual OpenLabs event. For this, we are shooting videos with a 360-degree camera at our experimental station Gut Höfchen and in the laboratories. On the virtual platform, participants can discuss the filmed study with our experts and ask questions.





# Strict *standa*





*Our planet is both a habitat and a source of food: That's reason enough to keep the impact of modern crop protection products on humans and the natural world to a minimum – a complex task in many respects.*

*Bayer researchers are particularly focused on the safety aspects of crop protection products – from environmental impact to food safety.*

Crop protection products protect crops from plant diseases, pests, and weeds. Combating these target organisms with crop protection products helps to secure harvests and ensure the global supply of healthy, high-quality food. So far, so good. But how does Bayer manage to avoid harming other plants and animals along with these target organisms and further reducing the planet's already fragile biodiversity? Also, who ensures that chemically treated foods are safe for human consumption and do not present any sort of risk? The Monheim-based Environmental Safety Division, which employs nearly 150 scientists, and the Residue Analysis team make an important contribution here.

#### **Impact on nontarget organisms**

An ecotoxicological study of the potential impact of a crop protection product is vital for protecting organisms that are not the target of the crop protection product or its active ingredient. To that end, tests are carried out with a range of plants and animals in Monheim – from mites, beetles, and earthworms to fish, daphnia, and algae, some of which live in the 15 artificial ponds on the Bayer campus. Bayer is also studying the effects of crop protection products on various ►

roads



Food safety is a sensitive issue that is extremely important to consumers.

Crop Science is ...

## // SAFE

*The Crop Science Division at Bayer produces products that offer the highest possible degree of safety for both consumers and the environment and that contribute to maintaining the biodiversity of our planet.*

species of plants, birds, vertebrates, and – above all – honeybees and their larva, as well as on bumblebees and wild bees. As pollinators, bees play a vital role in agriculture and the preservation of natural biodiversity.

### **Duration of effectiveness and amount of active ingredients**

The researchers at Bayer also want to learn how long an active ingredient can have an impact on the environment after its application, as well as how intense that impact will be. In this context, the term environmental exposure refers to the concentration of the product in the environment, and environmental fate to the length of time it remains in the environment.

In terms of environmental fate, one question might be how long it will take for a substance to break down in the soil, and what byproducts it might generate. Numerous studies –

under both standard lab conditions and in actual agricultural settings out in the fields – illustrate the path a substance travels as it breaks down in the soil, or how long it takes for an active ingredient to evaporate. If, for example, the half-life is less than two days, the substance will not spread across a wide area as it breaks down. The studies also examine the residue levels of a substance in the surface and ground water.

Based on all of these analyses, complex models can then be used to predict the post-application concentration of an active ingredient in the soil, water, or air with a high degree of accuracy.

### **Environmental impact assessment**

Finally, an environmental impact assessment is carried out based on the insights gleaned regarding ecotoxicology, environmental fate, and environmental exposure. The assessment investigates whether the projected concentrations in the environment present an unacceptable risk for nontarget organisms. A product will only receive approval for sale from the authorities and be deemed safe to use if these risks can be verifiably ruled out. Although the assessment models are different around the world, the basic principle remains the same: The correlation between toxicity and exposure is the most definitive indicator of environmental safety.

### **Responsibility and minimization of risk**

In addition to these highly scientific studies, a series of comparatively simple steps are required in order to protect the environment and uphold environmental safety. These steps place greater responsibility on both the farmers and the supervisory authorities. One example of the objectives of these minimization measures is to ensure that honeybees



## Safe for bees

Bees are granted extensive protection by the law – and for good reason. After all, as pollinators, they play a vital role in maintaining biodiversity, and the honey they produce is an important foodstuff. The government regulations imposed on crop protection product manufacturers regarding the correlation between the exposure and toxicity of their products are correspondingly strict. The risk assessments required for registration do not begin until a relatively late stage of the development process, however. Moreover, they determine whether or not a product is harmful to bees, but they do not explain why.

In order to make its crop protection products much safer for bees than legally required, Bayer is investigating the impact of its substances on bees in Monheim, taking a wide range of different aspects into account and starting in very early phases of biological research. Based on these observations and an improved understanding of the molecules, the company can make trend-setting decisions in the selection of substances. Apart from the molecular level, the individual bees and the bee colony as a whole are observed in order to analyze any harm caused to bees' offspring at various stages of development, for instance. Additionally, Bayer has a total of 60 to 80 bee tunnels. Each of these test systems is located on 50 to 100 square meters of semi-field testing space and provides everything bees need to survive. The systems also make it possible to simulate the real-life agricultural application of products in a self-contained complex. Multiple studies are carried out every season on different fields, and each one costs about €60,000. In conjunction with bee tests in laboratories, the goal is to determine how – and above all why – Bayer products have specific impacts on bee populations.

Cutting-edge technologies now complement the traditional lab and semi-field testing systems: As part of the Digital Hive project, beehives are being equipped with sensors that use a light barrier to indicate how many bees fly in and out and how many of them do not return to the hive. The temperature and humidity in the hive are constantly monitored, as are the sound frequencies the bees produce. Researchers at Agronomic Solutions translate this data into biologically relevant information in order to understand the impact that a temperature increase or decrease of one to two degrees Celsius can have on the beehive.

Other ongoing projects at Crop Science involve the simulation of bee behavior in mathematical models – yet another method that puts Bayer at the vanguard of bee protection.

have as little contact as possible with crop protection products. This might involve bans on spraying during the blooming period – a simple but effective solution.

Another dimension is product responsibility. This primarily comprises practical aspects of farmers' day-to-day work – from proper application of crop protection products to appropriate handling of empty containers. Good training and proper consultation are important here; the Bayer campus in Monheim is also developing the content for these training programs.

### Focus on safe foods

In addition to environmental safety, consumers are particularly interested in food safety. Residue Analysis makes a significant contribution here by using complex, highly sensitive measurement technology to determine what concentrations of which substances remain in foods that consumers will ultimately eat. Concentrations in the range of 0.01 milligrams per kilogram are measured here – essentially, it is as though the researchers are trying to find approximately 5 square meters that exhibit certain properties, but these 5 square meters are distributed across the entire 535-square-kilometer surface area of Lake Constance. This meticulous detective work is entrusted to a total of 50 employees in Monheim – from chemists and lab technicians to agronomists – who carry out tens of thousands of measurements every year. In addition to cutting-edge, high-tech equipment, this work requires incredible feats of logistics.

The end result is data that quantifies how much of a crop protection product will remain in the crops harvested if the farmer had applied it correctly in the field. This data information is incorporated into the approval data package submitted to the regulatory authorities for the registration ►





authorization of a product. After assessment, the authorities determine the maximum amount of residue that is permitted to remain in food, and government-run laboratories are responsible for monitoring compliance with these limits.

Because residue in our food is a sensitive issue, it is of great interest to our visitors, farmers, and representatives of institutions who often come to Monheim. Descriptive analogies are used to explain the high level of safety to them: For example, in order to consume enough sufficient amounts of the crop protection product Spiroxamine to cause concern, an adult would need to eat 1,000 kilograms of grapes or drink 1,600 liters of wine in a day.

In the last 15 years or so, the requirements imposed by regulatory authorities have become significantly more stringent: Much greater effort is required to collect data that accurately represents agricultural practices, and the measurement methods are becoming increasingly sophisticated. And the number of tests trials has increased dramatically: For example, in order to provide representative data to the EU regarding potential crop protection product residue in wheat, tests trials need to be carried out in 16 different locations. ◀



*Spray tests at Bayer's in-house testing station Gut Höfchen.*

## Precise application

Application technology plays an important role in the safety of crop protection products: For example, when spraying a field, how can you prevent the neighboring field of flowers – home to rare species of birds or insects – from coming into contact with pesticides? How do you ensure that the user sitting in the tractor cab has as little contact with chemicals as possible? And how can you reduce the amount of chemicals used by applying them more precisely? Agricultural technology





*Drone applications are also tested with specific product formulations at Gut Höfchen.*

might not be part of Bayer's business model, but the company has a major vested interest in ensuring that its products are used safely and efficiently.

In Monheim, Dr. Torsten Balz and his team are responsible for the field of application technology. Dr. Balz, who holds a doctorate in phytopathology, grew up on a farm himself and knows what's important to farmers when it comes to applying crop protection products. "We need to ensure that organisms that are not the target of our products are protected from their effects, and we need to prevent our products from being wasted." One of the ways they are tackling these challenges is by working with nozzle manufacturers to find methods of reducing drift – the amount of atomized spray carried off by the wind. Nozzles are tested in wind tunnels and on the field, and laser technology is used to take highly detailed measurements. Bayer's in-house testing facility at Gut Höfchen, not far from Monheim, is used for this purpose; it is one of 60 testing facilities worldwide. The goal is to increasingly homogenize the size of the droplets, which will allow for the most consistent distribution and duration of effectiveness of the substances on the crops. Not only do the results benefit the nozzle manufacturers; they also provide Bayer with insight regarding the effectiveness of its products with different water spray rates and droplet sizes. These semi-field tests are also underpinned by preliminary lab tests, during which physical properties such as foaming, crystallization, solubility, and the stability of solutions are analyzed.

New solutions such as drip applications are also being tested: This approach uses irrigation hoses, which normally supply plants with water slowly and consistently

through minuscule holes, to apply systemic crop protection products – products that are absorbed through the root system and distributed through the plant.

Additionally, Dr. Balz is working on drone applications: "Currently, drones can only carry a maximum load of 10 to 15 liters, so every liter of spray solution is just additional weight that limits the area of output," he explains. "So the solutions have to be ten times more concentrated, and the product still has to remain dissolved during application. We need to look at how it behaves with nozzles and filters, and what impact the concentration has on its effectiveness." It's a fascinating issue – and it's just one of many, as Dr. Balz says. Given the many complex challenges with major relevance for farmers, he and his team expect to work on a wide range of interesting projects involving the safe application of Bayer products in the future.

***"Bayer has a vested interest in ensuring that its products are used safely and efficiently."***



**Dr. Torsten Balz,**  
Head of Application Technology

*Bayer is not only consistently working on its own carbon neutrality but is also supporting sustainable farming for the benefit of future generations.*



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*When it comes to sustainability, the Crop Science Division at Bayer isn't just addressing the issue internally; it is establishing new standards for the entire industry. In that sense, the company is taking a leading global role in reducing environmental pollutants in every aspect of agriculture.*

In fall 2019, the Bayer Group set very specific sustainability goals that make one thing very clear: The company assigns environmental and economic concerns equal weight. Responsibility for the climate, environment, and society has the same priority as financial success and financial commitments to shareholders. This ambitious approach goes so far as to tie management board salaries and employee bonuses to achieving the sustainability goals within the next 10 years.

The company's vision is "Health for all, hunger for none." Realizing that vision will involve improving the quality of life for as many people around the world as possible while protecting the Earth's natural resources. To that end, by 2030, Bayer will do the following:

- **100 million smallholder farmers** in countries with low to moderate levels of income will receive support from Bayer to help them feed themselves and others; Bayer will improve their access to expertise, products, and services (see the article on smallholder farmers starting on page 52).
- **100 million people** in disadvantaged communities will gain access to everyday health, as the products they need will be made available and they will be educated on the subject.
- **100 million women** in countries with low to moderate levels of income will gain access to modern contraceptives in order to promote the future economic and social development of the world through the advancement of women. ►

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In the area of climate protection, in particular, Bayer will do the following by 2030:

- Make all of its locations **carbon neutral**.
- Reduce the **greenhouse gas footprint** generated by the cultivation of important crops using Bayer crop protection products by 30 percent.
- Reduce the overall **environmental impact** of crop protection products by a total of 30 percent.

In terms of protecting the climate and the environment, the Crop Science Division at Bayer has triple the responsibility: First, the production of its products accounts for approximately 85 percent of the total 3.7 million tons of CO<sub>2</sub> that the Group emits. This is an issue the division definitely needs to tackle (see box “Reducing our footprint,” page 50). Second, agriculture is one of the main emitters of greenhouse gases overall; in addition to carbon dioxide, these gases include nitrous oxide, methane, and ammonia. The use of crop protection products is linked to the release of these gases into the atmosphere to a certain degree. The third and final aspect is the crop protection products

themselves. The impact they have on the environment as pollutants must be reduced and restricted further.

As Head of Sustainability and Business Stewardship, Dr. Klaus Kunz is a sort of top-ranked sustainability watchdog at Bayer in Monheim. “The issue of sustainability has gained significant traction in recent years,” he says. “Nearly every day, governments, scientists, businesspeople, NGOs, and societies around the world are confronted with new challenges, problems, or obligations involving sustainability – and they are looking for solutions. If we hope to surmount these challenges, we need to reorient ourselves as a company: We need to treat profitability and sustainability as two sides of the same coin, not as separate challenges. That is the only way we can make a relevant impact. And we need to ensure long-term acceptance of our approach within society – we need a license to operate.”

***“We need to treat profitability and sustainability as two sides of the same coin.”***

**Dr. Klaus Kunz**, Head of Sustainability and Business Stewardship



Dr. Klaus Kunz is a sort of top-ranked sustainability watchdog in his role as Head of Sustainability and Business Stewardship.

### **Four pillars – one success story**

The Crop Science Division at Bayer is building on four pillars to ensure the success of its strategic and operational integration of environmental and economic challenges. The first pillar is a focus on the major challenges of our time. “The health of bees, for instance, is just one facet of the overarching issue of biodiversity. We want to look at the issue holistically, and to do the same with the challenges of food safety and environmental protection,” Dr. Kunz explains. “We chose our areas of focus based on the United Nations Sustainable Development Goals as well as on models such as “planetary boundaries,” which was developed by a group led by Swedish resilience researcher Johan Rockström.” The second pillar is about perspective: Right from the beginning, all activities will be viewed from the perspective of farmers. “In this way, we ensure that we can translate our ideas into a business model that is feasible for farmers – one that they can adapt for practical application,” Dr. Kunz says. The third pillar is based on internal coordination: “The research and business divisions will discuss and coordinate all activities and work together to implement them. This allows us to guarantee that all of our approaches are feasible and marketable.” The fourth pillar of the Crop Science Division at Bayer’s sustainability strategy is vital for ensuring its credibility: “Every step on the road to meeting these goals must be objectively measurable and traceable – not just for us, but for the mem-



bers of the public we want to share in our journey and our success,” Dr. Kunz explains.

For example, gathering data on environmental pollution caused by crop protection products is a highly complex task. “Environmental pollutants comprise an entire orbit of challenges,” says Dr. Kunz. “You are sometimes working with files of 100,000 pages, half of which focus entirely on these environmental impacts. The challenge here is to reduce complexity while ensuring the highest possible level of reproducibility, credibility, and transparency.”

### Determining environmental impacts

Bayer is the first company in the agricultural industry to apply an externally developed model to its entire portfolio. The model was developed in cooperation with the University of Copenhagen and is used to determine the environmental impact of crop protection products in all cultures around the world. In addition to the chemical and biological profile of the products, it also takes into account aspects such as the type of application, the timing of the application, and the application rate.

“We always used to talk about the impact of our crop protection products,” Dr. Kunz says. “In our early research, we were only looking for chemicals that would combat a certain fungus or pest, as though we were searching for a needle in a haystack – and we did that for 100,000 to 200,000 substances per year. Now that we have introduced new toxicity and environmental safety tests into this early phase of research, we can store more information about the side effects of molecules and filter for the substances we want to track at a much earlier stage.”

Consequently, replacing older chemicals with newer ones is a continuous, sustainability-oriented process. As the initial application of the model to the global portfolio demonstrates, Bayer’s market share is already much higher than the share of the overall impact of crop protection products. In that sense, it is hardly surprising that Dr. Kunz has a somewhat nuanced opinion of the European Green Deal. “In our view, only focusing on halving the amount of crop protection products by 2030 is a rather one-dimensional approach,” he explains. Qualitative aspects such as the application method have an enormous influence on the environmental impact, but they are not being taken into account, he adds. It would be better and much more meaningful, he points out, to focus on the environmental impact and how to limit it – and that is exactly Bayer’s goal. ►



*Varieties of soy that no longer require pesticides to combat grubs contribute to reducing environmental pollution.*



*A Crop Science agrobiologist inspects vegetable plants at a greenhouse in Monheim.*

Crop Science is ...

# // SUSTAINABLE

*The Crop Science Division at Bayer uses science and technology to make a significant contribution to improving agricultural crop yields while reducing environmental impact.*

"We are talking to all stakeholders – in industry, in the food supply chain, and in politics – as well as to investors in connection with this issue. We have to reward farmers for producing food in an environmentally friendly way," says the Head of Sustainability. And he expressly includes the possibilities presented by breeding and genetic engineering in this thinking: "If, for example, I grow a variety of soy in Brazil that no longer requires pesticides to combat grubs, that can make a huge contribution to reducing environmental pollutants." It's important to come together and consider all the options and technologies available, without prejudice, he says. "The best possible agriculture consists of an optimum mix of all available tools. Just as we can learn a great deal from organic farmers, they can also learn a lot from us – we just need to get out of our ideological bunkers and communicate with each other, without preconceptions." A great deal has changed for the better here in the last five years, he says. Climate change has made it very clear that there needs to be a shift in mindset – and that sustainable farming is an urgent issue. ◀

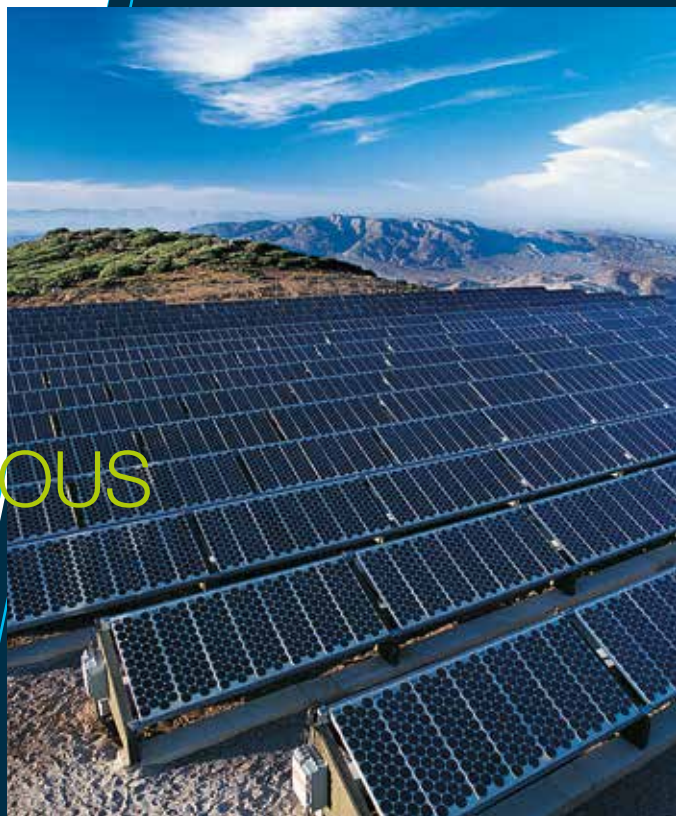
## Reducing our footprint

Bayer plans to be carbon-neutral by 2030. To that end, the Crop Science Division at Bayer needs to reduce its own carbon footprint by 40 percent.

Crop Science is ...

## // CLIMATE-CONSCIOUS

*The Crop Science Division at Bayer supports farmers around the world in reducing carbon emissions from agriculture and changing production methods to allow for carbon neutrality by 2030.*



Bayer prefers to source its electricity from providers that supply green energy.

For decades, Bayer has been committed to protecting the environment and the climate, to energy efficiency, and to lower carbon emissions. The integration of industry giant Monsanto did not make the associated challenges any less difficult to tackle: Within the Bayer Group, the Crop Science Division at Bayer – and especially the Product Supply department it encompasses, which is responsible for production and employs around 18,000 people at 126 locations around the world – is the largest carbon emitter. All activities to reduce the Group's own carbon footprint are managed centrally from Bayer's headquarters in Monheim, where approximately 300 employees work for Product Supply.

"Naturally, we're not starting at zero," says Dr. Sigurd Buchholz, Head of Corporate Citizenship. "Given the high standard of the climate protection measures we've already implemented, however, there aren't many more adjustments we can make easily." Despite having already optimized many processes, his department still needs to reduce emissions by more than 40 percent in order to contribute to limiting global warming to 1.5 degrees Celsius. "To achieve this goal, we need to go over all our systems and processes with a fine-tooth comb once again and optimize them even further," Dr. Buchholz explains. The goal is to compensate for heat loss, increase efficiency, and reduce energy consumption: "Basically everything you would do in a private household, just on a much larger scale." This includes energy-efficient equipment and the responsible, energy-efficient operation of systems as well as improved insulation and optimized ventilation. Few of the more than one hundred projects the teams are managing and supporting from Monheim will have an enormous impact by themselves, but all the small steps eventually add up, Dr. Buchholz explains: "It's a painstaking process, and we sometimes hit a brick wall. There is trash that has to be burned and processes that have to emit CO<sub>2</sub> by nature. Any areas we can't decarbonize, we have to offset through actions such as reforestation." Within the next ten years, the division will invest €200 million solely in these sorts of measures and a wide range of other offsetting projects.

Consequently, the consistent use of renewable energies is a major factor here; it is set to account for approximately three quarters of the planned reductions in carbon emissions from production, Dr. Buchholz says. The Bayer Group plans to source 100 percent of its electricity from renewable sources and sustainable production in the future. "As a major customer, we can also make a difference in the regions where our production

## ***"Bayer is at the vanguard of environmental protection and sustainability goals."***



**Dr. Sigurd Buchholz,**  
Head of Corporate  
Citizenship

facilities are located. We source electricity from partnerships with utility companies that are breaking new ground – whether that's a solar energy park in Spain or a provider in Kansas City, USA. In this way, not only do we secure the green energy we need; we also help to drive and expedite the process of adopting new methods of supplying electricity." Bayer hopes to achieve this goal worldwide by 2030 – with assistance from suppliers, whose energy profiles must be evaluated and need to meet certain sustainability criteria.

### **Consistent Standards**

In order to document the progress along this path as credibly and objectively as possible, the company needs to define reliable measurement parameters that apply across all sectors. Bayer produces an annual progress report on its sustainability efforts. Additionally, the independent Science Based Targets Initiative (SBTi) audited Bayer AG's environmental protection goals and confirmed that Bayer is doing its part to limit global warming to 1.5 degrees Celsius. "Driven by our mission, 'Science For A Better Life,' Bayer is at the vanguard of these efforts," says Dr. Buchholz, pleased. When "Handelsblatt" recently ran a comparison of 500 companies' sustainability goals, Bayer was among the top three percent. "We are already playing a leading role here. We want to use our strong market position to exert pressure within our industry so that others will follow our example." And there are many signs that this will be a promising endeavor.



Approximately 550 million  
smallholder farmers  
around the world meet  
more than half of the  
demand for food in  
developing countries.

A woman with dark hair, wearing a white dress with pink floral patterns, stands in a field of green chili plants. She is smiling and holding a large bunch of green and red chili peppers in front of her. In the background, another person wearing a straw hat is visible, working in the field. The sky is clear and blue.

# Enabling sec income



*By the year 2030, Bayer plans to improve access to agricultural expertise, products, and markets for 100 million smallholder farmers. Through empowerment and societal transformation, the company is helping to facilitate secure incomes and combat poverty in previously underdeveloped regions of the world.*

While the approximately 2 million farms in the USA are nearly 180 hectares on average, the median size of a farm in sub-Saharan Africa is just 2.4 hectares. In Asia, that figure is just 1.8 hectares. There are an estimated 550 million smallholder farmers around the world who farm parcels of less than ten hectares. They meet more than half of the demand for food in developing countries. As such, they play a key role in securing the food supply for the growing global population. Many of these farmers have little opportunity for education and insufficient access to agricultural subsidies or loans, which prevents them from fulfilling their potential; they can barely survive on their poor yields.

"The combat to inequality and poverty around the world is a challenge far too big to be taken up by governments alone," explains Dr. Lino Dias, who has been Vice President Smallholder Farming in the Crop Science Division at Bayer since 2015. "Large corporations have a responsibility here, too. At Bayer, our strong commitment to support this is reflected in the fact that board members' salaries are partially tied to reaching our sustainability goals, rather than merely to the financial success of the company."

For this reason, Bayer set ambitious sustainability goals in late 2019 that will serve as benchmarks for judging its

***"We're not trying to create good PR photos here. We are trying to start a sustainable transformation."***



**Dr. Lino Dias,**  
Vice President Smallholder Farming

performance – not just by a critical public, but by investors who are increasingly interested in how companies will ensure their own relevance and acceptance in society over the long term. In the field of pharmaceuticals, Bayer wants to help 100 million women in countries with low to moderate levels of income gain access to responsible family planning by 2030. During the same period of time, the Consumer Care Division plans to provide access to everyday preventative healthcare products for 100 million people in underprivileged areas around the world. Finally, the Crop Science Division at Bayer wants to make it possible for 100 million smallholder farmers from less affluent countries to improve their income through agricultural innovation, expertise, and partnerships along the supply chain by 2030. The objective is to secure the local food supply and effectively combat poverty.

"Like scientific innovation, social responsibility is in our genes," Dr. Dias emphasizes. "The Bayer pension fund is a good example. It was established in 1887, years before

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a government pension system was introduced.” ►

And Bayer's work with smallholder farmers isn't new, either: “In India, for example, the smallholder farmers have been the focus of our work for over 120 years. That helps us understand their needs culture.”

The target group is anything but homogeneous, so the same strategy cannot be applied everywhere, explains Dr. Dias. Some of the farmers are well educated, have sufficient resources, and earn enough money, he adds, but the poorest of the poor struggle every day to get enough to eat, and they have no access to financial opportunities or markets where they could sell their crops. Bayer's goal is to help the farmers improve every aspect of their work, from the field to their business models.

“We're not trying to create good PR photos here. We are trying to start a sustainable transformation,” Dr. Dias says. And, of course, to develop a market: While Bayer needs to make enormous investments in its existing markets in order to increase its market share by just a tenth of a percentage point, the smallholder farmers harbor enormous potential that benefits everyone involved. For example, a Bayer pilot project with around 10,000 farmers families in 2017 generated revenue of one million euros, and the added value for the farmers was estimated in about €13 million. “That's a win-win-win situation,” says Dr. Dias happily. “The farmer does good business, society

benefits, and Bayer also gets something out of it.”

Better Life Farming is an example of the diverse range of concepts, programs, and products intended to tap the smallholder farmers' potential. Program partners include the IFC, an international development bank that funds private companies as part of the World Bank Group; Netafim, one of the world's largest manufacturers of artificial irrigation systems; the insurance company Swiss Re Corporate Solutions; and more than twenty partners in India, Indonesia, and Bangladesh.

### Unexpected support

In the Indian state of Uttar Pradesh, for example, Better Life Farming provided support for the cultivation of green chilies. 1,600 farmers were trained in the latest crop management methods, integrated pest control, and precision irrigation systems. Their yields increased by over 100 percent, and their income actually tripled. The government of Uttar Pradesh took notice and offered its support for the program. Thanks to exceptional conditions certificates of exemption for the sale of crop protection products, Bayer and the farmers were able to scale the project more quickly than originally planned. “If you had asked me five years ago what my dream would be, I would have said: I wish a government would ask us how it can help us implement our concept,” Dr. Dias says with a laugh.

Today, that dream has become a reality: In Indonesia, where there are now 82 Better Life Farming Centers, the president even expressed praise for the program recently. “The concept of an ecosystem consisting of different partners has proven itself here. It's much easier for politicians to cooperate with these networks than to tie themselves to a company, which is primarily interested in profit,” Dr. Dias explains.

The Better Life Farming Centers train farmers in subjects such as crop selection, soil preparation, and crop rotation. This expertise is taught in a practical way that is adapted to the local culture; listeners sit in little tents on chairs or on the ground. Bayer introduces its products and explains how to apply them correctly. Bankers present an app that allows farmers to apply for loans and pay their electricity and water bills. Representatives of the food industry then explain their requirements in terms of quality, packaging, and unit sizes.

The ongoing pandemic, in particular, has presented smallholder farmers with enormous challenges. Bayer and a range of partners took the initiative here and launched a comprehensive three-phase Covid-19 response program. Currently, the focus is on care packages with products and safety instructions; over the medium to long term, the goal is to ensure stability and safeguard expertise and digital solutions.

Crop Science is ...

## // RESPONSIBLE

*As part of its sustainability strategy, Bayer plans to improve access to agricultural expertise, products, and services for 100 million smallholder farmers in developing regions by the year 2030.*



*Bayer employee Diana Gitonga advises a smallholder farmer in Kenya on the best way to grow his potato plant.*

### **A model for success with empowered women**

The model farms attached to each Better Life Farming Center give the farmers a chance to experience how the program works in real life. And the fact that it works is beyond question: In addition to India and Indonesia, Bangladesh now has its first centers, and a number of African countries are next on the list. The Better Life Farming Centers have also achieved success in another area recently: They are getting women actively involved in the value chain. According to the Food and Agriculture Organization of the United Nations (FAO), women make up just under half of all farmers. Despite this statistic, women have not been addressed in most campaigns in developing countries up to this point, although men in certain rural regions are not even allowed to talk to women. Bayer employs female agronomists and appoints women as owners of Better Life Farming Centers to ensure that these women farmers feel respected by members of their own gender and can operate in an environment where they can discuss agriculture as women – economic transition must go hand-in-hand with societal change.

“In order to reach our target of 100 million, we will need to be patient, build networks, establish trust, and set up value chains,” Dr. Dias explains. “Then, we will experience a success story in which the farmers produce more, earn more, and improve their lives – with our technology, ex-



*BLF opens BLF Centers to actively support women in establishing financial independence.*

pertise, and innovative solutions. We wouldn't be able to achieve our ambitious goal through sales of seeds and crop protection products alone.”

All departments at Crop Science have been considering the needs of smallholder farming and providing resources for some time now. “Everything is going in a direction that I couldn't even have imagined five years ago,” Dr. Dias says, pleased. “Why are we all pulling together? Maybe because our shareholders and society as a whole consider this an important issue worth their attention. But certainly because the results on the ground demonstrate that we are having an impact.” ◀



# Our Bayer cam *in Mon*

*Around 2,000 people from over  
40 countries work together in Monheim  
am Rhein. On the approximately  
65-hectare Bayer campus, they find  
the strength to effect change and a  
culture shaped by a passion  
for innovation.*



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research  
institutes  
are located  
on the Bayer  
campus

*“WITH ITS  
JAPANESE  
ARCHITECTURE AND  
ITS VARIETY OF  
SHAPES AND COLORS,  
THE **CAMPUS IS A  
SPECIAL PLACE**, AND  
THE TROPICARIUM  
IS QUITE  
SENSATIONAL.”*

DR. BOB REITER,  
Head of Research & Development

From **Monheim**  
to the world






Space

*for ideas*





*Bayer provides its employees with ideal working conditions and fertile ground for innovation in Monheim am Rhein. People from around the world work together in a range of institutes, nestled in a veritable park, in an effort to improve the future of agriculture in a lasting way.*

65 hectares with expansive parks, surrounded by acres of farmland: This is the Bayer campus in Monheim am Rhein, the global headquarters of the Crop Science Division at Bayer and its most important research site. An impressive population of trees, streams, and bodies of water underscore the expansive feel of the campus. And in fact, the campus provides the approximately 2,000 Bayer employees who work here with the literal and figurative space they need to find inspiration for new ideas. Chemists, biologists, engineers, lab technicians, and businesspeople work on the campus, all pulling together to achieve their shared goal of shaping the future of agriculture. The campus is characterized by the greenhouses and laboratories of the complexes housing the nine institutes, as well as the administration building – with its distinctive curved lines – and even the scale of the buildings themselves: None of the buildings are taller than six stories. The highly unique appearance of the entire complex is timelessly modern,

a seamless design that clearly signals how Bayer has consistently invested in the development of the Monheim location for the last 40 years.

The heart of the Bayer campus is the Tropicarium, which opened in 1981. Seeing it for the first time, you could be forgiven for thinking that an enormous UFO had landed in a pond in the middle of a beautiful park. You cross the slender, curved bridge to enter the company restaurant, the cafeteria, or the conference rooms located inside the Tropicarium. However, the stunning focal point of the building is a miniature jungle with more than 300 mostly tropical crop plants – from avocados, bananas, and African mahogany trees to fruit trees, cinnamon, rice, and sugarcane. For these plants from all regions of the

*The Tropicarium is the heart of the Bayer campus and houses the company restaurant and conference rooms.*

world to flourish under the circular glass roof requires ► masterful gardening and sophisticated technology that can simulate a range of different environmental conditions in a space of just 300 square meters.

### Youth programs and a look behind the scenes

Every two to three years, the Bayer campus in Monheim holds an open house, offering the public the chance to experience the site first-hand. Tours are also conducted year-round; visitors can get a look behind the scenes and gain insight into the research conducted by the institutes and labs. It is important to get young people interested in the natural sciences at an early age, which is why Bayer launched the Baylab program especially for students in 2009. As part of this program, approximately 1,000 students get to experience the world of natural sciences up close every year. The focus here is primarily on teaching chemistry and biology: The amateur scientists conduct their first biotechnological analyses on the Crop Science research campus. For example, they learn how cooking oil is made from rapeseed and which parts of plants are used to produce biofuels. The young researchers also discover a great deal about how research and development works at a global company. Bayer additionally offers programs during school vacations for interested students.

### Company daycare center

One of the many other benefits that makes the Bayer campus in Monheim an attractive place to work is the company's own daycare center. The name says it all: "Die Sprösslinge" (Little Sprouts – the German term is a nickname for children) is a reminder that plants aren't the only thing growing in Monheim. Up to 70 children, aged six months to school age, receive the best possible care here all year round. For many parents, the daycare center

is a huge help as they juggle work and family life. And the daycare center is also environmentally friendly: The building, which has won awards for its architecture, produces all the energy it needs by itself, without any carbon emissions at all.

### A Livable and lovable location

People who start their careers at Bayer in Monheim are joining a Life Science company that proactively promotes a healthy work-life balance. In addition to the usual factors a global company requires, such as good infrastructure and ideal transportation connections, Monheim – a city with a population of 43,000 located in the Cologne Lowland region – provides the perfect combination of green surroundings and urban life, of tranquility and activity. It is



As part of its youth programs, Bayer welcomes interested students into its labs.

## Monheim Milestones

### 1965

The construction of a crop protection research center is considered for the first time.

### 1977

Bayer purchases a 60-hectare property in Monheim am Rhein.

### 1977/1978

Bayer announces an international architecture competition for its new crop protection center.

### 1979

The foundation for the Bayer crop protection center is laid.

### 1982

The first phase of construction is completed: office building, Tropicarium, biological research (fungicide), power plant, workshops.

### 1985

The second phase of construction is completed: chemical research, ecobiology, metabolism research, residue analysis.



September 1979: Architect Kisho Kurokawa (center) with co-planners Friedrich W. Bertram (left) and Jörg Schuler.

## CONSTRUCTED METABOLISM

# Building for the future

an idyllic place to live, and employees particularly appreciate the city's proximity to the Rhine River and its quaint historic district, which features the "Schelmenturm" (a medieval tower), the "Gänselieselbrunnen" (a fountain in front of city hall), the lovingly restored historic buildings, and the cafés, bars, and inviting beer gardens. Monheim is also popular for its many parks and recreational facilities, both in the city itself and in the surrounding area. Cologne and Düsseldorf, both major cities with extensive cultural activities and opportunities for shopping, are just a few minutes away.

The nearby airports make arrivals and departures convenient and easy for business partners. The city is well-connected to the European highway network via the A 3, A 59, and A 542 highways. And Monheim is easy to reach on public transportation, with buses and commuter trains arriving and departing in rapid intervals. ◀

When planning the agricultural center in Monheim in the late 1970s, Bayer wants to achieve nothing less than a quantum leap with the construction of its research facilities: The central architectural design motifs include the facilitation of communication and the consummate flexibility of the facilities, which are conceived so that they will be easy to adapt to future working conditions and methods. Bayer holds an architecture competition to find the right concept for the facility, and Kisho Kurokawa's design takes the top spot. He is one of the leading minds of a movement known as "Metabolism" – a group of Japanese architects who view architecture as an organic life cycle.

Before the process begins, the designers conduct interaction studies and consult cybernetic models to create the best possible conditions for scientific work. A story in the Bayer newsletter at the time focuses on a scenario in which two researchers happen to run into each other on the way to the center's cafeteria; they begin to discuss their research and come up with new ideas in the process. This story still shapes the design of research centers all over the world today.

### 1988

The third phase of construction is completed: biological research (insecticides and herbicides), arthropod breeding (for household and hygiene pests), formulation technology.

### 2000

Substance logistics and the UHTBS system (Ultra High Throughput Biochemical Screening) launch operations.

### 2001/2002

Bayer acquires the crop protection division and the seed department from Aventis.

### 2002

Bayer Crop Science AG is founded; the Monheim site becomes the company's headquarters.

### 2015/2016

Bayer invests approximately €80 million in maintenance and new construction and in improving its research infrastructure.

### 2016

Crop Science is converted back into a division of Bayer AG.

### 2018

Completion of new building: Institute of Insecticides

Bayer acquires Monsanto and integrates the company into its Crop Science Division.



# At home on the campus

## 2.5 million

substances are stored by the Crop Science Division at Bayer –  
the world's largest collection of active ingredients for the  
agricultural sector.



## 300

square meters of jungle  
provide a home to exotic  
plants in the Tropicarium.

## 2,000

researchers  
from 40 nations.



## 1,000

students visit the student labo-  
ratories in Monheim every year.

## 80 million

euros is the total investment Bayer made in the maintenance  
and expansion of the Monheim campus in 2015/2016.

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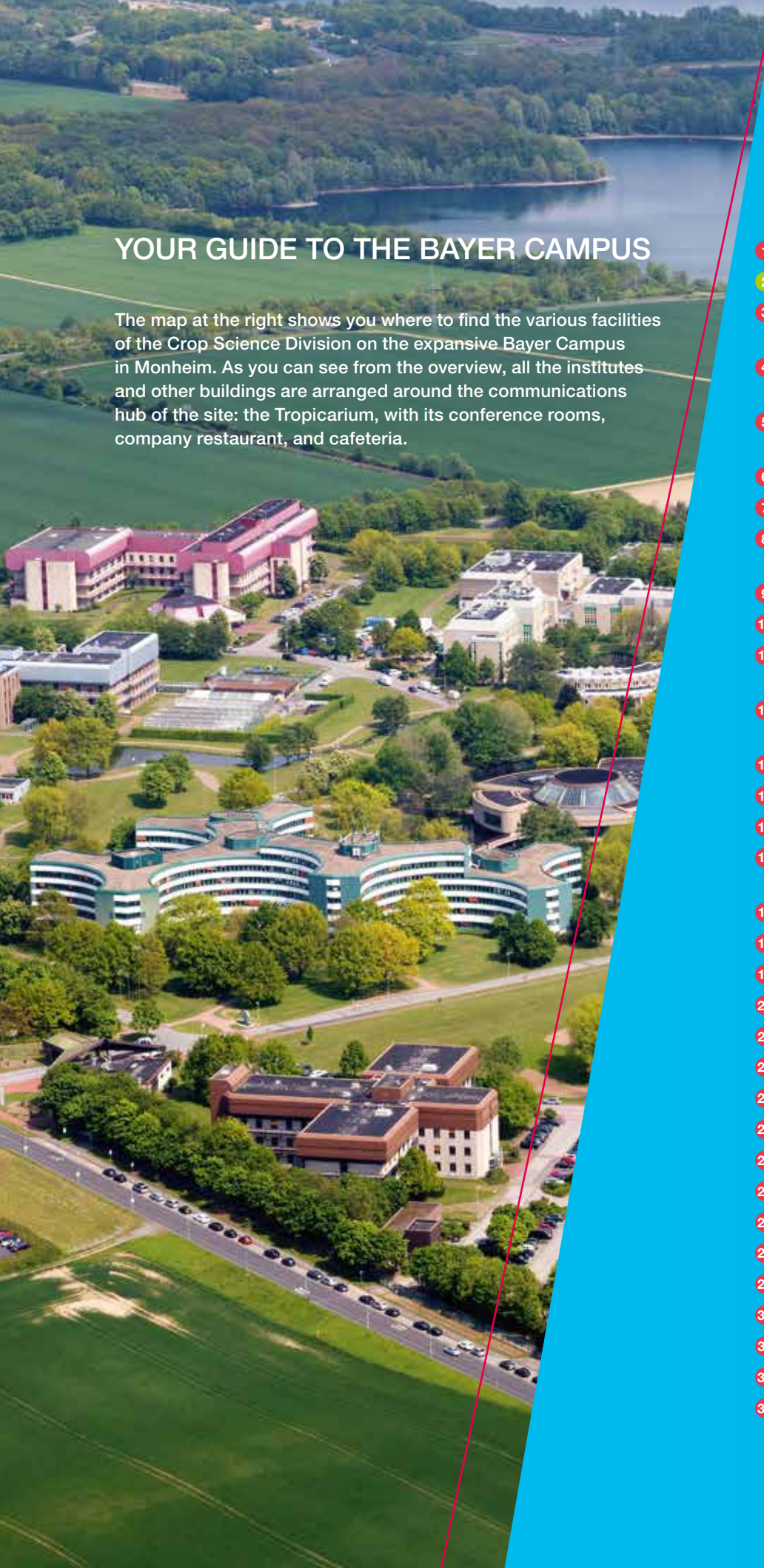
*\* To improve readability, the third-person singular masculine form is often used throughout the text. No gender discrimination is intended.*





# YOUR GUIDE TO THE BAYER CAMPUS

The map at the right shows you where to find the various facilities of the Crop Science Division on the expansive Bayer Campus in Monheim. As you can see from the overview, all the institutes and other buildings are arranged around the communications hub of the site: the Tropicarium, with its conference rooms, company restaurant, and cafeteria.

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- 1 Gate 1
  - 2 Tropicarium
  - 3 Company Headquarters Administration
  - 4 Biology & Biochemistry Fungicides/Target Research
  - 5 Biology & Biochemistry Insecticides
  - 6 Office Building
  - 7 Substances Library
  - 8 Chemical Synthesis/Analytics/Processes
  - 9 Formulation Technology
  - 10 Institute of Ecotoxicology
  - 11 Institute of Metabolism and Environmental Research
  - 12 Institute of Residue Analysis, User and Consumer Safety
  - 13 Greenhouses
  - 14 Apiary
  - 15 Office Building
  - 16 Site Management, Workshop Engineering Technology
  - 17 Heating and Power Station
  - 18 Student Laboratory
  - 19 "Die Sprösslinge" Daycare Center
  - 20 Elanco Animal Health GmbH
  - 21 Gate 2
  - 22 Gate 3
  - 23 Grain Drying/Storage
  - 24 Office Building
  - 25 Sample Shipping Office
  - 26 Application Technology Center
  - 27 Seed Growth Center
  - 28 Office Building
  - 29 Warehouse
  - 30 Business Center
  - 31 Testing Facilities
  - 32 Warehouse
  - 33 Conference and Office Building





Haupt-eingang

Visitor  
Parking

Alfred-Nobel-Str.

Heide

Heerweg

Industriestr.

Rheinuferstr.

Rhine





[www.bayer.de](http://www.bayer.de)

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