

FUTUROLOGY:  
THE FUTURE GAME RULES

TEST TRACK  
FOR COATINGS

# ELEMENTS

MARCH 2017

# 58

FOR A GOOD  
GUT FEELING\*





**Our experts on the future are  
masters of the yoga of ideas:  
in 58 exercises to the best solution.**

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 **EVONIK**  
POWER TO CREATE





Where are the future unicorns (billion-dollar startups) to be found? **Page 12**

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## EDITORIAL

### Openness

If machines take over tasks which previously required experience and visual and tactile capabilities, will it make humans superfluous? Evonik's new high-throughput system for conducting fully automated formulation and testing of coatings proves just the opposite. While the machine performs routine tasks reproducibly and accurately, a person controls the experiments and provides the necessary creativity for coming up with new solutions. This allows Evonik to shorten the development time for coating additives and to accelerate the pace of innovation.

Evonik also saw success in other innovation areas in 2016, for example in the production process for thermoelectric generators, which convert waste heat into electricity. It was a development for which Creavis, our strategic innovation unit, received the renowned German Innovation Award in the Research category. Other achievements were recognized with the Evonik Innovation Award 2016: an intelligent concept that enables us to sustainably optimize our polyester production network, and a new product that brings about a further reduction in the rolling resistance of tires and thus also in fuel consumption.

All of these innovations add value—for the environment, for the economy, and for society. The researchers behind these innovations took an objective, open-minded approach to new things and collaborated intensively with other business lines, companies, and scientists. For me, this openness is at the core of the innovation process. And it is for this reason that our 2016 CIO Award went to an employee who is committed to open innovation, and with great success: Prof. Robert Franke, whose readiness to share his knowledge is also evident in the number of papers he has published together with external researchers.



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# NOT JUST CHICKEN FEED

**Which probiotics are beneficial in livestock farming? What is the best way to analyze and document their effects in the digestive tract? Evonik is working with partners to develop an innovative, dynamic simulation model of the chicken gut. The resulting insights will help to increase health and efficiency in farming and reduce the use of antibiotics in chicken husbandry.**



*Peter Freisler, Dr. Christoph Kobler,  
and Prof. Dr. Stefan Pelzer*

**G**lobal demand for meat is steadily rising as population growth, urbanization, and improved standards of living drive up the consumption of animal proteins. According to estimates by the United Nations Food and Agriculture Organization (FAO), global meat production will be approximately 40% higher than current levels by 2050. The FAO therefore sees efficiency increases based on modern feed additives as a core element of sustainable livestock farming.

Functional additives such as probiotics, prebiotics, organic acids, enzymes, plant extracts, and mineral zeolites are already widely used and are associated with numerous positive effects on feed conversion, health, and animal growth. However, the mode of action of some of these feed additives is still not fully clear. In the case of probiotics, this is mainly due to the fact that the role of microbiota—the entirety of intestinal bacteria—is not yet well understood.

It has been known for millennia that many diseases have their origin in the gut. Pathogenic bacteria in the intestinal tract can cause symptoms and physical ailments virtually anywhere in the organism. The intestinal mucous membrane has a wide range of functions. It contains glands that form enzymes for breaking down nutrients, cells to transport substances from →

What happens in the gut of a chicken? How can intestinal flora be positively impacted? A new intestinal simulation model from Evonik provides the answers to these questions.



→ the intestine to the blood, and the body's largest arsenal of lymphocytes, i.e. cells that defend against pathogens.

### Good or poor health is determined in the intestines

The interaction between feed ingredients, the intestinal mucous membrane, and the intestinal flora determines the health of farm animals, but large parts of this interaction have not been scientifically studied and are not yet understood in detail. The only certainty is this: When these substance interactions are out of balance, animals become ill.

In the absence of suitable models for efficiency analysis, animal feed additives such as probiotics used to be developed empirically, a knowledge gap Evonik wants to close. Together with its partners, the Animal Nutrition Business Line in the Nutrition & Care Segment has started a project to develop an innovative gut simulation model, which will enable the scientific study and analysis of intestinal processes occurring in farm animals. The six-year GOBI ("Good Bacteria and Bioactives in Industry") innovation alliance has a project volume of up to €9 million and is funded by the German Federal Ministry of Research. In addition to Evonik (GOBI Feed) the alliance includes the biotech enterprise Organobalance and Bionorica SE. Organobalance focuses on the

human digestive system (GOBI Health GI), while Bionorica is researching the role of the microbiome in respiratory illnesses (GOBI Health RT). The synergies between the project partners primarily pertain to methodological approaches.

In the first phase until 2018, Evonik will concentrate on establishing and validating the gut simulation model for broilers and the *in vitro* analysis of feed additives. The objective of Phase 2 is to develop new probiotics and feed additives that can improve feed conversion and chicken health. Evonik researchers from Halle-Künsebeck will be cooperating closely with the ProDigest BVBA company from Ghent, Belgium. The experts at ProDigest specialize in biological and chemical gut processes and came up with a simulation model of the human digestive tract years ago.

Feed additives are not a new business area for Evonik. For many years, the company has been producing essential amino acids for farm animals, which improve feed conversion and save limited resources.

Evonik has not been active in the probiotics market with products of its own so far. Probiotics are not defined chemical substances but living bacterial cells. They are able to produce substances that support digestion, promote metabolism, inhibit the growth of pathogenic bacteria, modulate the immune system, or stabilize the intestinal flora.

The most commonly used probiotics in poultry farming include *Bacillus* strains and lactic acid bacteria. Bacteria of the genus *Bacillus* are known for their ability to produce various enzymes and antimicrobial substances. In addition, their spores are able to survive the high temperatures of feed pellet production unscathed.

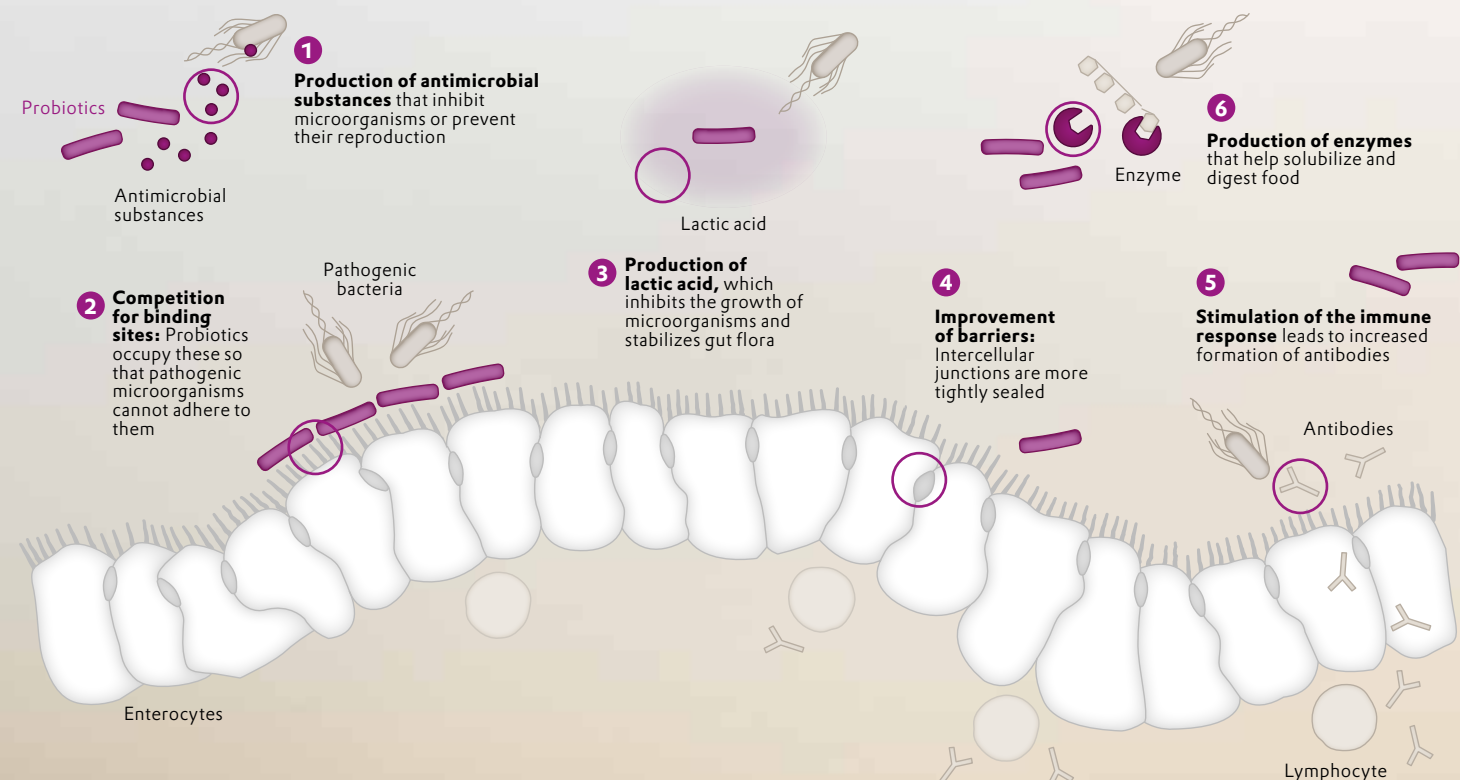
Lactic acid bacteria produce lactic acid in the intestine, which inhibits the growth of other bacteria and is converted to butyric acid in the lower intestinal tract by anaerobic bacteria. Chickens use butyric acid as an additional source of energy. This short list already makes it clear that the analysis of probiotic action mechanisms requires a systemic approach and cannot be described by a few unique reaction equations.

The gut simulation model will for the first time offer an *in vitro* model of the numerous interactions between feed, the immune system, and intestinal microbiota in chickens by means of scientific methods. It will capture essential parts of metabolic and physiological processes in the intestine. This

## The analysis of probiotic action mechanisms requires a systemic approach.

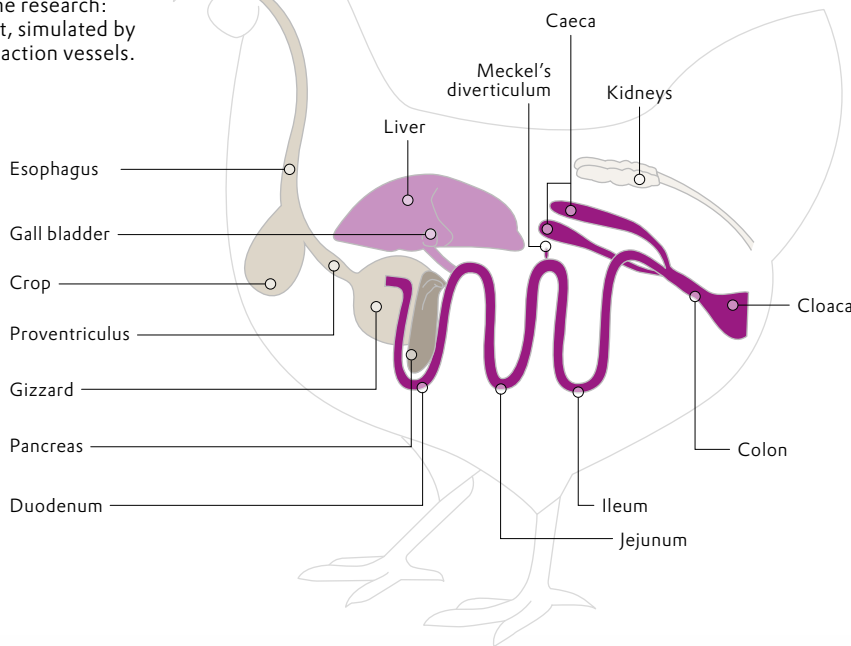
### How probiotics work in the gut

Probiotics can positively influence gut microbiota in many different ways, for example by preventing pathogenic microorganisms from adhering to the gut wall or by stimulating the immune response. The diagram shows schematically the most important mechanisms of action.



### The digestive tract of the chicken

The focus of the research: the chicken gut, simulated by a cascade of reaction vessels.



will allow researchers to clarify fundamental questions about metabolic and immune processes but will also enable them to test new probiotics and select the most effective candidates among various choices.

### Simulation model builds a bridge from laboratory to farm

However, even the best model can only approximate reality. The *in vitro* experiments will therefore be followed by *in vivo* feeding trials to validate the laboratory results. The gut simulation model of GOBI Feed thus builds a broad bridge between the *in vitro* laboratory world and the *in vivo* world of applications in livestock farming.

The term “model” makes many people think of computer-simulated virtual representations. However, that is not the case with the gut simulation model. Rather, it consists of a cascade of glass reaction vessels that are connected in a specific sequence. Each vessel simulates a certain digestive segment of the chicken gut by representing its physical, chemical, and microbiological conditions. The scientists are using the experiences of ProDigest in the field of human intestinal simulation and are taking the specific characteristics of broilers into account in the development of the new model. For example, chicken digestion is subject to different temperatures and intestinal pH values. Instead of a long colon, chickens have two caeca, and their microbiota has a different composition than that of humans.

To approximate the reality of livestock farming as closely as possible, the model simulates the natural food intake of the animal in multiple cycles as well as the cooperation of individual intestinal segments specific to chickens. How efficiently are nu-

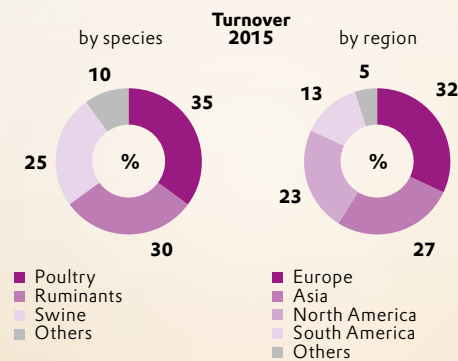
trients digested and absorbed in the individual segments? What is the composition of a standardized bacteria mix that can be used to inoculate the reactors to represent the intestinal flora as precisely as possible? The research team will investigate fundamental questions of this kind in the coming months.

Immune modulation represents a particular challenge in the project. Which biological factors determine the immune defense of the animal? For this purpose, the researchers are using cell cultures, where the pathogen-host interaction takes place and the immune response of the host is simulated. Suitable cell cultures for chickens, however, are rare. It is therefore an important task to find and develop better cell lines to study questions of immune modulation in the absence and presence of additives and

### Sales of probiotics for livestock

The turnover in livestock breeding in 2015 was about US\$900 million. The largest share of this was for poultry farming, with Europe as the largest market.

Sources: MarketsandMarkets, Evonik



pathogens. The gut simulation model will move from its current location at the partner company ProDigest in Ghent to Nutrition & Care in Halle-Künsebeck in the fall of 2017. The laboratory at Evonik’s Halle site has been remodeled to create the required infrastructure for the necessary immunological, physiological, and microbiological testing.

Knowledge leads to targeted prevention—this is the premise of the GOBI Feed project. The gut simulation model will contribute to a substantial reduction in the use of antibiotics in animal nutrition. In many countries of the world, antibiotics are mixed into the feed not only to treat acute illnesses, but also as a growth promoter and for pathogen prophylaxis. As a negative consequence of this practice, resistant bacteria proliferate, the spread of multi-resistant pathogens is accelerated, and the produced meat frequently contains antibiotic residues. Feeding so-called antibiotic growth promoters (AGP) has been banned in the EU since 2006.

Although the substances are still added to feed in large quantities in other regions of the world, there is increasing consumer demand for meat produced without such substances in countries such as the United States. Thus, the chicken fast food chain Chick-fil-A in 2014 announced that its North American restaurants would only sell AGP-free chicken meat. McDonald’s followed suit in 2015 with a similar announcement, but limited itself to antibiotics which are also used in human medicine.

### Helpful bacteria instead of antibiotics in the feed

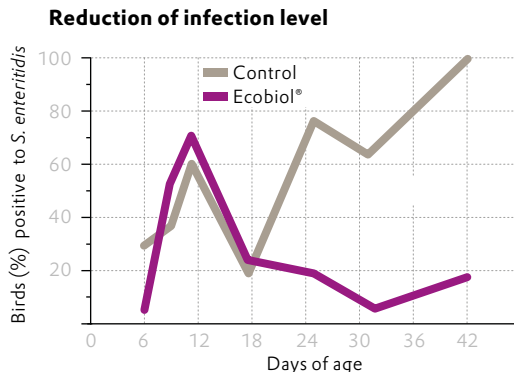
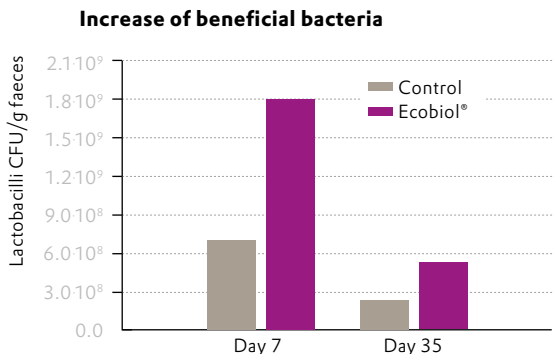
The objective of GOBI Feed is to develop probiotics that have a similar effect and are comparable in use to AGP. To that end, their effect first has to be better understood—with the help of the gut simulation model. Where to start the search? There are a number of strains with a wide range of different benefits for animal nutrition. Even before starting the GOBI project, the experts at Nutrition & Care, using a well-selected set of less complex methods, performed a successful screening with *Bacillus* bacteria, which have the proven ability to inhibit pathogenic bacteria by producing inhibiting substances and by stimulating local immunity in the chicken gut.

To find the most effective candidates, some 500 different *Bacillus* strains were compared on the basis of two dozen different characteristics. For example, essential criteria included whether the strain was able to germinate and grow in the presence of bile acid and acidic pH and whether it produced certain antimicrobial and pro-digestive substances.

Two of the analyzed candidates proved to be particularly potent in laboratory tests. One of them ultimately became the new probiotic GutCare® PY1 for use in chicken farming. The new additive showed con- ➔

**Effective probiotic**

Ecobiol®, a fast-growing strain of *Bacillus amyloliquefaciens*, promotes the growth of useful lactic acid bacteria in chicken gut (left; CFU = colony forming unit) and reduces *Salmonella enteritidis* infection (right).



→ **vincing results in feeding studies:** Its effect on growth and the general condition of broilers, including in the presence of pathogens, was comparable to that of the previously used feed antibiotics. The expression of subclinical necrotic enteritis—a disease that frequently occurs in chicken breeding—was significantly reduced.

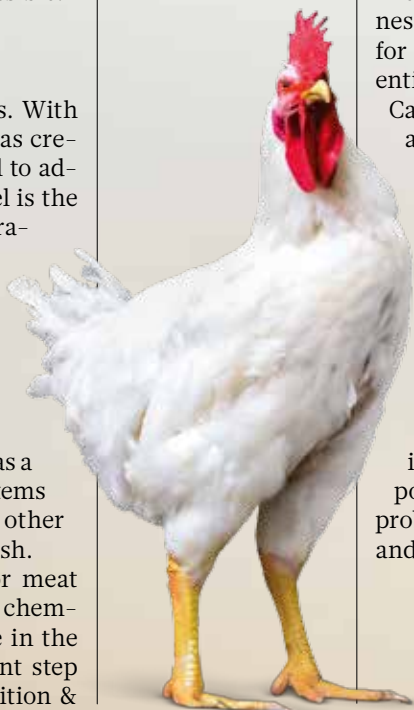
The market for feed additives is keeping pace with the world’s growing hunger for meat. The global market for probiotics is currently around US\$950 million and according to market observer estimates is expected to grow at an annual rate of six to ten percent. Europe currently comprises approximately one third of sales, while the US and Asia each account for about a quarter. The market still has a lot of potential, but is not an easy field. New products have to show the same positive effects as AGP in farming and be just as economical. At the same time, they must be safe to use for humans and animals, easy to dispense and store, and should continue to increase the profitability of farming further if possible.

**Closing significant knowledge gaps**

That’s a lot of different expectations. With the gut simulation model, Evonik has created a modern, multifunctional tool to address these requirements. The model is the basis for the analysis and demonstration of the probiotic mode of action and closes significant knowledge gaps. It rationalizes the search for new additives and opens a pathway toward animal farming that is efficient and yet needs far fewer antibiotics in the feed or none at all. Ultimately, Evonik will use the model as a platform to develop comparable systems and other functional additives for other livestock animals such as swine or fish.

By developing new probiotics for meat production, Evonik as a specialty chemicals company is changing its place in the value chain and taking a significant step toward the consumer market. Nutrition &

Probiotics can help keep broilers healthy without the use of antibiotics.



Care plans to introduce the new probiotic GutCare® PY1 in the United States and China in 2017. Evonik also created a first foothold in the European market when it took over the probiotics business of the Spanish company NOREL in July 2016. The transaction added a number of products to the Group’s portfolio that already have regulatory approval and have proven their value as additives in feed and drinking water. One such product is Ecobiol®, a fast-growing *Bacillus amyloliquefaciens* strain. It inhibits the effect of pathogens in the chicken gut and promotes the growth of beneficial lactobacilli. Thanks to its acquisition of NOREL, Evonik is able to benefit from the dynamic development of the European market in the short term.

Farmers and breeders must work efficiently and economically to remain competitive. At the same time, there is growing pressure from consumers and animal rights organizations to make nutrition and farming conditions healthier and more animal-friendly. As a consequence, the business with probiotics involves challenges for communicating and cooperating with entirely new stakeholders. The Nutrition & Care Segment plans to develop the associated adapted marketing and communication strategies and will set up comprehensive new competencies to give the right answers in a market that is calling for explanations.

This will focus on the triad of knowledge, product, and service—a vital approach that will set Evonik apart from the competition. The company has earned a solid reputation as a scientifically oriented, reliable partner in the area of animal nutrition. It will position itself in the same manner in the probiotics business by precisely explaining and documenting how its products work. ●

**The experts**



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The innovation alliance “Good Bacteria and Bioactives in Industry” (GOBI) is funded under the registration no. 031B0074 A – C within the German Federal Ministry of Education and Research framework “Industrial Bioeconomy.”



## Guest commentary

# The power of the microbiome

*Dr. Jana Seifert, assistant professor*

The microbiome in the human and animal gastrointestinal tract forms a unique symbiotic relationship with the host organism. While it plays a central role in maintaining the metabolic performance and health of the host, it can also have negative consequences. Changes to the microbiome affect interactions both among microorganisms and between microorganisms and the host—and, as a result, they also impact our health.

Bacteria, archaea, fungi, protozoa, and viruses are the most important groups in the gastrointestinal microbiome. This diversity is important for making efficient use of nutrients, producing useful microbial metabolic products, and being able to minimize undesirable substances (such as methane from ruminants).

Microorganisms begin colonizing the digestive tract during birth and this dynamic process continues throughout an individual's life. The composition of the microbiome varies from one individual to the next, and is influenced not only by the genetic makeup of the host, but also by the individual's nutrition and the available nutrients. Not all microorganisms in the intestines play a positive role—undesirable, potentially pathogenic species are there as well.

It was not until the development of new sequencing and bioanalytical methods that we had the ability to study the microbiome in more detail. Methods based on nucleic acids, for instance, offer insight into its composition and potential function. In addition, protein-based analyses yield information about metabolic pathways and about the expression of microbial proteins. Analyzing metabolites



**Dr. Jana Seifert** is the recipient of an endowed assistant professorship in "Feed-Gut Microbiota Interaction" at the University of Hohenheim Institute of Animal Science. She is also a member of the scientific advisory board for the "Good Bacteria and Bioactives in Industry" (GOBI) project sponsored by the German Federal Ministry of Education and Research.

**“If we want to use probiotic strains systematically, we need a better understanding of microbial activity in the host.”**

reveals the products of metabolism, but cannot be used for drawing conclusions about their sources. While the focus of initial research in the field was purely descriptive, incorporating these new methods allows scientists to continuously improve functional characterization of the microbiome. Scientists can characterize individual species in extensive detail and observe the actual effects of microbial activities on the host (gut-brain barrier). This knowledge is a prerequisite for selectively stimulating certain microorganisms in the digestive tract or for introducing probiotic strains for better health.

It follows that a better understanding of the microbiome and its internal and external influencing factors is extremely relevant to human and animal health. If we are to achieve this understanding as effectively as possible, researchers of human and veterinary medicine will need to work together closely.

DATA MINING

# Trillions of bodyguards

Trillions of bacteria live in the human gut. Their metabolic products boost immune defenses and can even have an impact on mood. Probiotic foods can help to sustain the microbial balance in the body. They contain live microorganisms that exert their positive effect in the gut. An insight into the workings of the human gut and into the market for probiotics.

## All about the gut

The gut of an adult measures **7-9 meters in length** and is the most important digestive organ.

Source: German Society of Mucosal Immunology and the Microbiome



Today, we eat around **75% less fiber** than we did 100 years ago.



The intestine has a surface area of **300 m<sup>2</sup>**.



Over the course of our lives we consume an average of **40 metric tons of food** and **50,000 liters of fluid**.



The gut is where the main part of the **human immune system** is located.

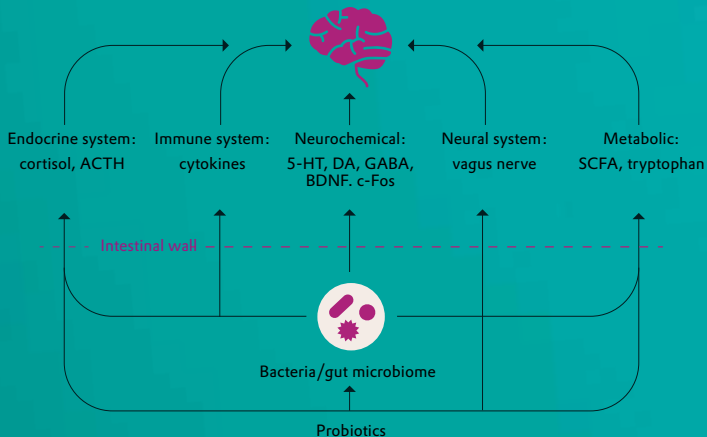


The bacteria in the human gut weigh **around 1.5 kg** in total.

## The belly and the brain

The bacteria in the gut interact not only with the immune system via their metabolic products but also with the brain through various signaling pathways such as the vagus nerve. There, they can influence feelings of well-being or anxiety.

Source: Wang et al., J. Neurogastroenterol. Motil. 22 (4), 2016, 589-605



## Japan in the lead

At US\$126, people in Japan spend the largest amount per year on functional foods, a group which also includes probiotic foods.

Source: Dixit Y. et al., J. Food Microbiol. Saf. Hyg., 1 (111), 2016

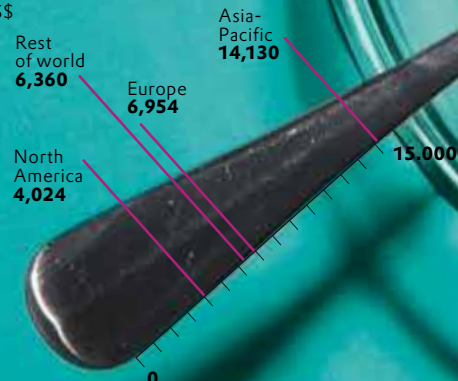
Annual per-capita expenditure in US\$

## Strong growth

In 2014, the market for probiotic functional foods was worth US\$31.5 billion. The biggest regional market is Asia-Pacific, predominantly Japan. The market is expected to grow to at least US\$46 billion by 2020.

Source: Dixit Y. et al., J. Food Microbiol. Saf. Hyg., 1(111), 2016

Data in million US\$



## A look inside shopping carts

14,059 Europeans took part in a survey which asked "How often do you buy these food items that advertise health benefits?"

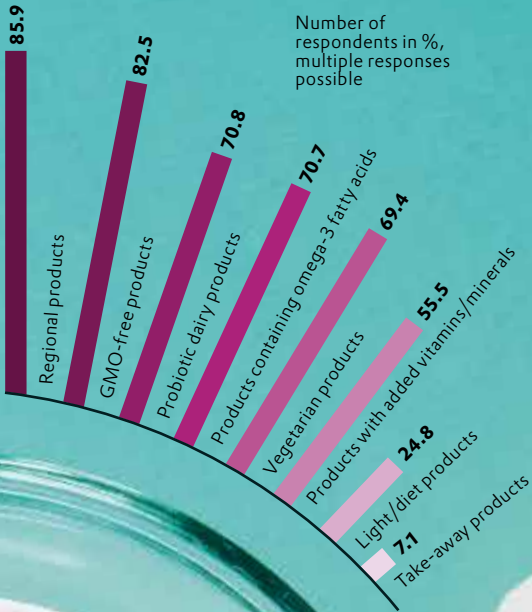
Source: Nielsen, ©Statista 2016



**“Regional” is considered healthy**

500 German consumers were asked “To what extent do you regard the following products as healthy/health-promoting?” Regional products took first place.

Source: KPMG, IfH Köln, ©Statista 2015



Number of respondents in %, multiple responses possible

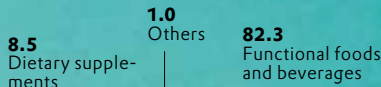


**Where are probiotics used?**

The main application area for probiotics is functional foods.

Source: Dixit Y. et al., J. Food Microbiol. Saf. Hyg., 1 (11), 2016

Data in %

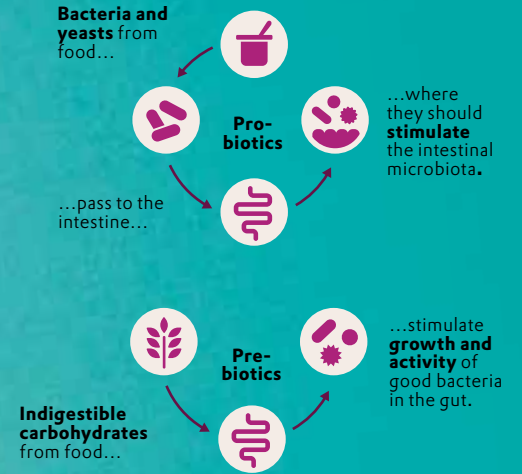


**Pro and pre**

**Probiotics:** live microbes such as bacteria and yeasts which reach the gut through food and which should then have a positive influence on health.

**Prebiotics:** indigestible carbohydrates which increase the amount of or activity of desired intestinal bacteria.

Source: Ministry of the Environment and Consumer Protection, German State of Saarland



...regulation of the immune system

**Important helpers**

The bacteria in the gut have a major influence on the body's biological processes. They support the...

Source: Seres Therapeutics



...protection of the body against disease-causing germs



...energy release from food



...production of essential vitamins



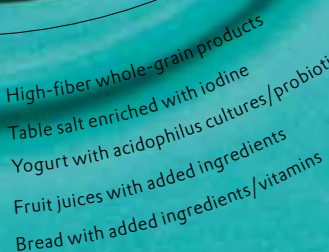
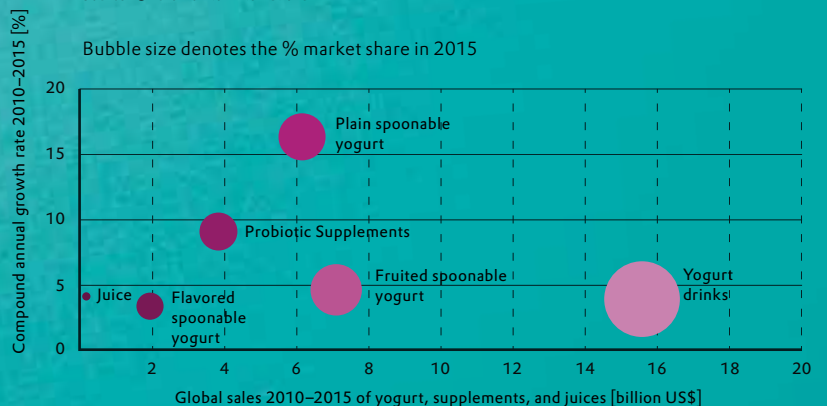
...control of metabolism and blood sugar level

**Most popular: probiotic yogurt drinks**

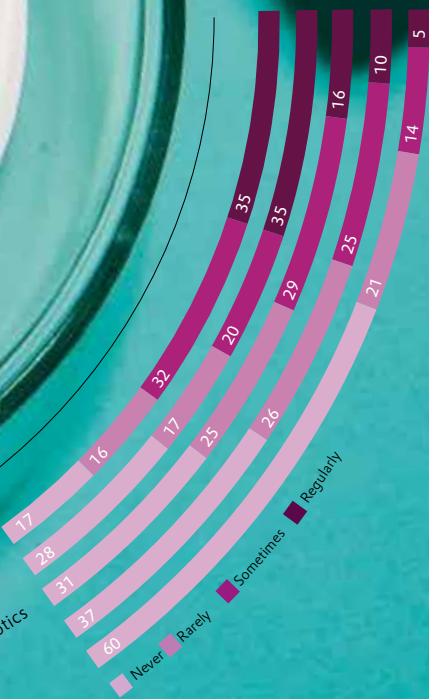
Yogurt is one of the most important probiotic foodstuffs. Between 2010 and 2015, yogurt drinks registered the highest sales and plain spoonable yogurt registered the greatest growth rate.

Source: ©Euromonitor International

Bubble size denotes the % market share in 2015



Number of respondents in %, figures rounded







# EDUCATION FUTURE EDUCATION

EVERY ONE IS TALKING ABOUT IT...  
... NO ONE IS DOING IT...

+ CROWD FUNDING...  
+ HOME EDUCATION...

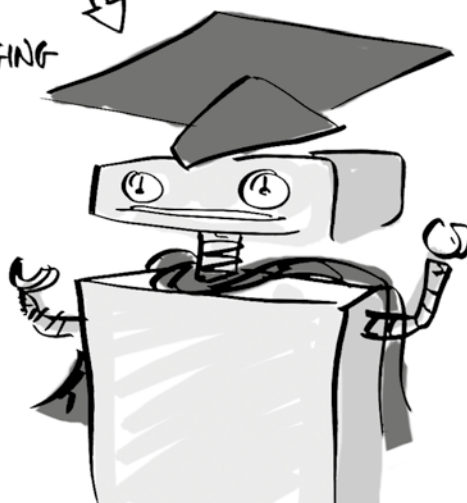


2025<sup>000</sup>

SOMETHING CHALLENGING IS HAPPENING...

TEACHERS COULD, SHOULD AND WOULD BE REPLACED BY ARTIFICIAL INTELLIGENCE

HELLO MR CHIPS



3D PRINTED FOOD



DINNER IS PRINTED!

REAL FOOD IS A LUXURY



Björn Theis

What is futurology? Does the Corporate Foresight team of Creavis, the strategic innovation unit of Evonik, use crystal balls and coffee grounds to predict the future? The answer of course is a resounding “no”. Futurology cannot predict the future; what it does is study current notions of the future based on the fact that the future is being made here and now—by everybody, every day. It’s the current political decisions, academic research projects, technical and social visions, and even small everyday decisions by individuals—the political party they vote for, for example, or whether they prefer a vegetarian diet or meat—that set the course for tomorrow.

For early identification of these pointers to the future in selected fields, the Corporate Foresight team works on what it calls focus topics and organizes an annual Foresight event. These events bring together experts in a variety of subjects and from many countries to discuss current developments and trends in a selected field. When working on the (now wound-up) focus topic of Digital Futures, for example, the team organized one of the first-ever Soft Robotics workshops in any country.

The current focus topic is titled GameChanger. The Foresight team applies the term to innovations or events that in the next twenty years have the potential to profoundly change existing markets, industries, or even entire societies; typical examples here are the steam engine, the Internet, and Brexit. The aim is to identify and analyze potential game changers early so as to be able to evaluate the opportunities or risks they present for Evonik.

To master this challenge, Corporate Foresight invited 50 international futurists from the corporate world, NGOs (non-governmental organizations), technology, and politics to the first dedicated GameChanger Workshop in Antwerp last September.

The question in focus at the workshop: What are the developments that will shape our lives in the future?



Among the guests were futurists from Audi, Covestro, VW, Innogy, Nestlé, the Joint Research Center of the EU Commission, and the Fraunhofer Society, among others, as well as representatives from various universities.

### Uncovering interdependencies

With this event, the Foresight team was pursuing two goals. First, it wanted to produce a “game changer map” displaying the collective knowledge of the participants on possible game-changing developments and showing interdependencies between the individual game changers. The second focus of the meeting was on the setting up of an international network of foresight experts.

The event opened with a keynote address by Dr. Tim Jones, founder and head of Future Agenda, the world’s largest open-source foresight program. In 2015 Future Agenda conducted about 120 workshops in 45 cities and 35 countries to be able to anticipate future changes. These allowed Future Agenda to identify, and present here, the six most potent game changers that could influence all of humankind.

One of these game changers is food waste. About 30 to 50 percent of all the food produced is thrown away, either because it has perished at some stage in the supply chain, for example through inadequate refrigeration, or because consumers buy it and then do not consume it. If this waste could be prevented by optimized distribution and storage, it would be possible to eliminate famine worldwide.

Future Agenda sees a second game changer in the development of platforms for data exchange. In the age of Big Data, data will be a form of hard currency. But the possessors of data cannot always exploit or monetize it. A platform for data exchange could solve this problem and also lead to a boom in technology and research, because primary data sets could be sources of new business ideas, products, and services. →

# THE FUTURE GAME RULES

**In the future, will medical patients pay for their treatment with their privacy? What would the future look like if energy were cost-free? And can the future also be taken away from us? At Creavis’ GameChanger Workshop in Antwerp, 50 renowned futurologists held discussions with representatives of the Group.**





A playful approach to the future: What could the energy supply of tomorrow look like, for example?

→ The third game changer cited by Future Agenda also concerns access to knowledge. According to Jones, an “education revolution” is in full swing. In his view the Internet is a true catalyst of global education. Particularly in third world countries, an increasing number of people are using the Internet to gain access to educational resources. Over the medium term this development will enable users in these countries to narrow the knowledge gap between them and people in the West, thus ultimately strengthening economic growth in their own countries.

**China—a possible game maker of the future**

Future Agenda’s fourth game changer is about a country that in many respects has already outstripped the West: Jones believes that China will soon be the nation setting global standards in business, ecology, and culture and demanding adherence to them. As a result of its continuing economic growth and the associated increase in its cultural, political, and military clout, China has advanced to a global power. And its government knows how to exploit this power to represent its interests globally.

Nearly Free Energy is the fifth game changer of Future Agenda. As a result of the increasing use of renewable energy sources, such as solar energy, and falling prices for this technology, we are approaching a future in which energy production will cost hardly anything at all. What are the possi-

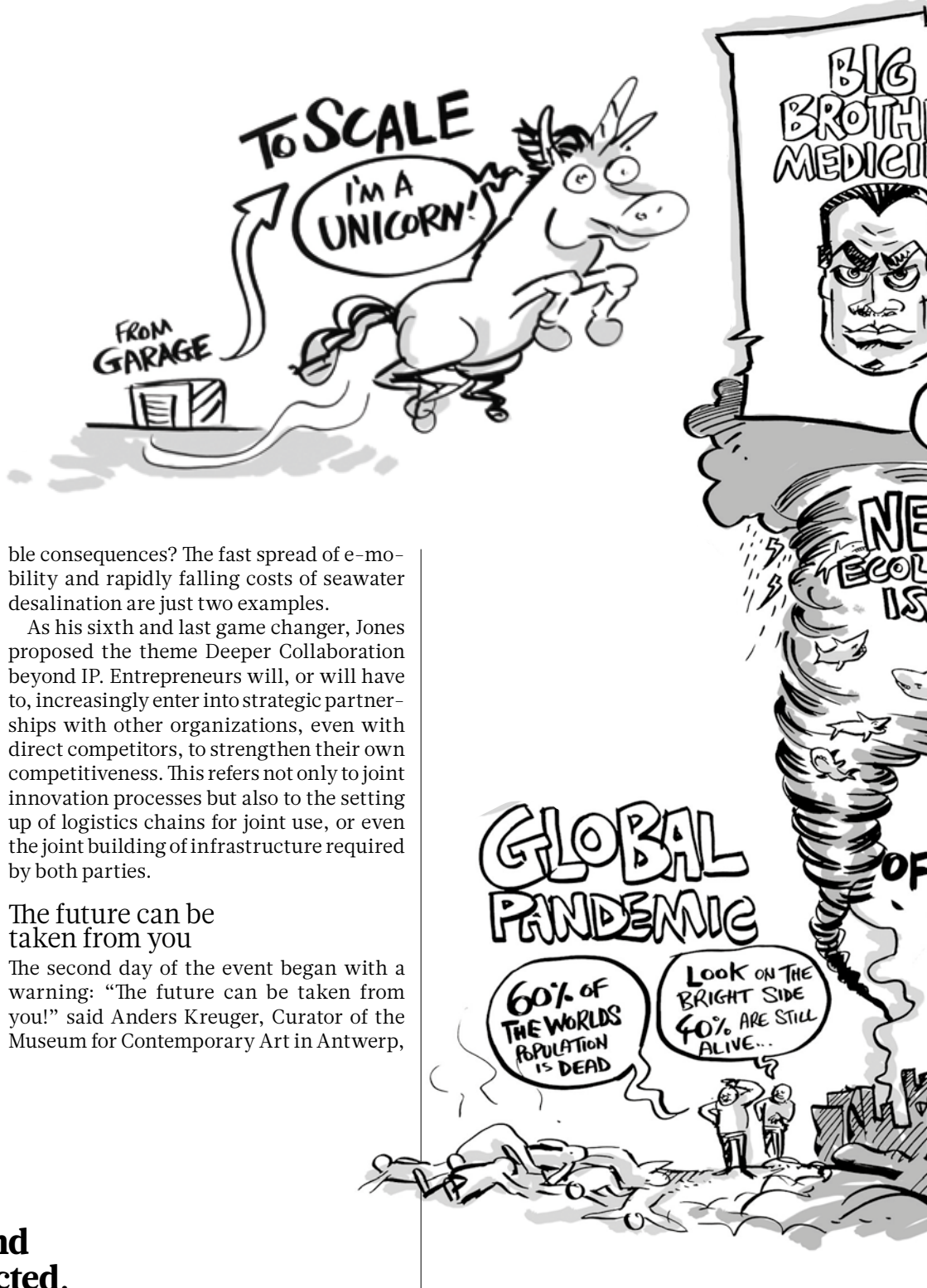
ble consequences? The fast spread of e-mobility and rapidly falling costs of seawater desalination are just two examples.

As his sixth and last game changer, Jones proposed the theme Deeper Collaboration beyond IP. Entrepreneurs will, or will have to, increasingly enter into strategic partnerships with other organizations, even with direct competitors, to strengthen their own competitiveness. This refers not only to joint innovation processes but also to the setting up of logistics chains for joint use, or even the joint building of infrastructure required by both parties.

**The future can be taken from you**

The second day of the event began with a warning: “The future can be taken from you!” said Anders Kreuger, Curator of the Museum for Contemporary Art in Antwerp,

**Education, energy, health, traffic, nutrition—these systems are not as stable and secure as is generally expected.**







**Graphic recording**

Threatening health systems, future lifestyles or the collapse of everything: No topic was taboo. All outcomes were graphically recorded.



**TRANSPORT 2040**



**SMART CITY**



**THE COLLAPSE OF EVERYTHING**



Photography: Sebastian ter Burg | Illustration: Chris Shipman

at the start of his keynote speech “Game Changing Synergies: What Foresight Can Learn from the Arts.” Kreuger pointed out that the desired future of one group could be diametrically opposed to other players’ perceptions of the future—as is exemplified by Brexit. The emergence of the future is thus a process potentially rich in conflict. In any analysis of possible futures, therefore, it is not merely useful but necessary to consider also those visions of the future lying at the boundaries between individual disciplines such as chemistry and art.

Inspired by these challenges, the participants then got down to work. After the Creavis Corporate Foresight team presented 21 game changers that it had previously identified, the participants were split up into five workgroups along the STEEP sectors. In futurology STEEP stands for Society, Technology, Economy, Ecology, and Politics. This division should ensure that in any analysis of the future, all factors influencing human society are taken into account.

The five individual workgroups were asked to identify, describe, and eval- →

**6**

**Game changers** can influence the entire population, according to Future Agenda.



→ uate the game changers for their sector that are the most relevant, in terms of their probability of occurrence and the magnitude of their possible impact on society. With this exercise, the Corporate Foresight team ensured that the participants' extensive knowledge of futurology was taken into account and a reliable overview of possible game changers in the individual STEEP sectors was obtained.

### Playful change of perspective to overcome blind spots

The second team exercise then allowed a playful change of perspective. Using a game specially developed by the Corporate Foresight team for the GameChanger meeting, participants were required to overcome blind spots in the identification of possible game changers. The five systems considered were education, energy, health, nutrition, and traffic, each of whose sub-items was represented by a toy brick. For example, every type of energy source, whether fossil fuels, solar energy, or nuclear energy, had its own brick. A roll of the dice decided which component of the system was to be considered. Once the component was decided, the players had to find game-changing innovations, supplements, and alternatives for it.

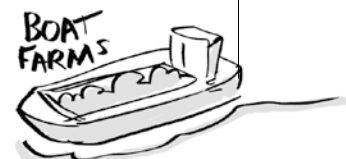
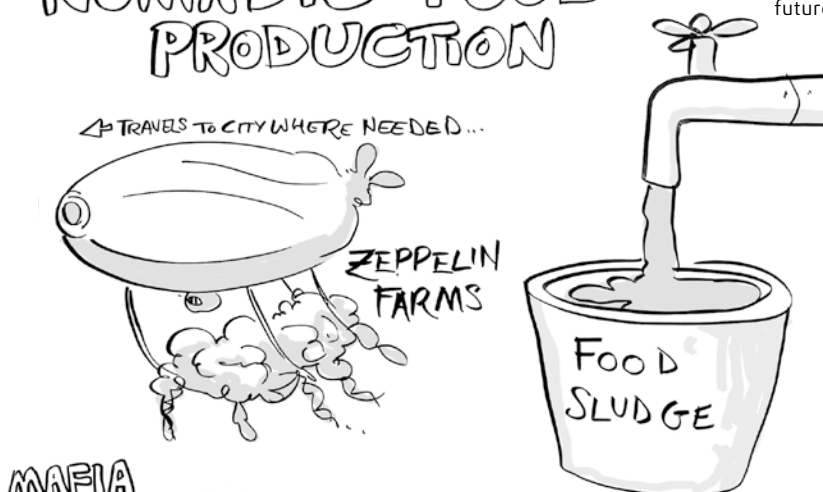
Among the ideas that the players considered was the possible impact on established health care systems if, for instance, Google teamed up with Pfizer to treat patients cost-effectively in their own hospitals, and in return received access to all patient data; and the possible impact on energy systems if a CO<sub>2</sub> tax were to be imposed on concrete and steel.

### Fascinating, surprising, sometimes alarming

The results of this session were surprising, fascinating, and occasionally even a little alarming. But the main lesson here was the realization that the selected systems—education, energy, health, nutrition, and traffic—are by no means as stable, secure, and immutable over the long term as

Another important goal of the event was to build up an international network of future researchers.

## NOMADIC FOOD PRODUCTION



is generally believed, a finding that is also immensely important for the specialty chemicals sector. The event concluded with the presentation of the results—the possibly game-changing innovations and incidents.

The Corporate Foresight team is now using the results in its own activities. Ahead of the event, the team members had already successfully identified 21 potential game changers. The discussions, insights, and new perspectives gained during the meeting enabled them to correct, refine, and expand this set in many ways. The result is a final set of game changers consisting of 24 potential changes that could affect Evonik in the future, such as the Age of Genomics (see also page 30). The task now is to derive from these game changers policies for innovation and strategy to ensure that Evonik will continue to call the shots in specialty chemicals in the future.

### The expert



**Björn Theis** is responsible for the GameChanger focus topic in Creavis's Corporate Foresight team.

*bjoern.theis@evonik.com*



# Company News

## MORE SILICA FOR MORE MARKETS

Evonik is acquiring the silica business of the US company J.M. Huber for US\$630 million. This enables Evonik to expand its position in North America and Asia in a profitable and resilient business.

The silica market shows above-average annual growth of four to six percent. Huber's business is especially oriented towards applications in the consumer goods industry, the dental sector for example. To date, Evonik's silica business has been focused rather on industrial applications, for example in the tire and coatings industries. "Combining the complementary silica businesses of Evonik and Huber will strengthen our Resource Efficiency growth segment," explained Christian Kullmann, Executive Board Member for Strategy at Evonik.

Silica from J.M. Huber is used in toothpaste, for example

For the 2016 financial year, Huber Silica is expected to achieve sales of close to US\$300 million and an EBITDA of US\$60 million. This corresponds to an attractive EBITDA margin of more than 20 percent. Through the ideal complementarity of the two business areas, Evonik expects to generate synergies of US\$20 million. Evonik expects to have all synergy measures implemented by 2021. On this basis, the purchase price (enterprise value) including synergies and tax effects is about seven times the annual EBITDA, or 10.5 times before tax effects and synergies.

The transaction is scheduled to be completed in the second half of 2017, subject to approval by the responsible authorities.

Evonik has a leading position as a supplier of silica for tire manufacturers and the paint and coatings industry. Evonik's silica products are also being applied as flow additives and carriers for the manufacture of foodstuffs, cosmetics, pharmaceuticals and silicones.

**More about silica:**  
<https://youtu.be/s2euB6YD3Yo>

More ROHACELL® →

More precipitated silica →

More biomaterials →



## Expansion for ROHACELL®

Evonik's Resource Efficiency Segment will invest in a capacity expansion of its Performance Foams business at its production site in Darmstadt (Germany). The investment will increase the output of the facility by about 20 percent as a first step. The Group will be adding production equipment to this operations complex,



Ice hockey sticks with ROHACELL® cores provide the highest possible puck acceleration.

which manufactures products marketed under the ROHACELL® brand. The expanded production capacity is expected to be operational by the second half of 2017.

Evonik's ROHACELL® brand has experienced double-digit growth in recent years. The ultra-lightweight foam is used as a core material in the construction of sandwich composites in aerospace, automotive, and marine applications, sports equipment, electronics, and medical technology. Components can be produced rapidly and efficiently, reducing production times and costs for the manufacturer.

## SEPAWA Award for biosurfactant

During this year's annual congress of SEPAWA Evonik was honored with the SEPAWA Innovation Award 2016 in the surfactant category. The jury rewarded the outstanding cleaning properties and the excellent ecological profile of the REWOFERM® bio-



The REWOFERM® biosurfactant is distinguished by outstanding cleaning performance.

surfactant. This sophorolipid is a powerful surfactant that is at the same time extremely gentle on the skin. It is readily biodegradable under both aerobic and anaerobic conditions and fully complies with European Ecolabel requirements.

REWOFERM® is manufactured from yeasts in an ecologically friendly fermentation process using only renewable raw materials (elements 55). With a Renewable Carbon Index (RCI) of 100 percent, it is the most sustainable secondary surfactant commercially available.

## Stretched PMMA sheets for aircraft

Evonik is constructing a stretching and polishing plant for PMMA sheeting for aircraft materials at the Weiterstadt (Germany) site, thereby further rounding out the company's product portfolio for cast and stretched PMMA sheets for the aviation industry.

Stretched PMMA sheets have enhanced impact and chemical resistance, making this material particularly suitable for the extremely high



PLEXIGLAS® GS 249 stretched for passenger cabin windows.

requirements of the aviation industry. The new plant producing stretched PLEXIGLAS® aircraft materials is the most advanced of its kind anywhere in the world. It is being erected directly adjoining the existing production facility for the cast PMMA blocks that are the base materials for the stretching process.

The investment will, in the future, allow Evonik—the world's only producer—to produce sheets in a format more than twice as large as is customary at present. One area of application where these are required in the production of larger aircraft windows.

## Professorship for Karl Kuhmann

In recognition of his many years of teaching in the Chair of Plastics Engineering (LKT), Dr.-Ing. Karl Kuhmann has been appointed an honorary professor at Friedrich-Alexander-Universität (FAU) Erlangen-Nürnberg (Germany).



Dr.-Ing. Karl Kuhmann (right) with the President of FAU, Prof. Joachim Hornegger.

Kuhmann is responsible for processing technology in R&D in Evonik's High Performance Polymers Business Line. In his teaching activities at FAU, he initially gave lecture courses focusing on injection molding techniques and then, together with Prof. Dr.-Ing. Dietmar Drummer, Chair of Plastics Engineering, a lecture titled "Composites with Plastics."

## Technology for methionine

Evonik and METabolic Explorer (METEX) of France have agreed that Evonik will acquire a technology package

from METEX to strengthen its biotechnology platform for amino acids. The package includes METEX's entire technology portfolio for the fermentative production of methionine, as well as patents, essential bacteria strains, and the inoLa™ brand.

The transaction also includes a back license agreement pertaining to certain patents to be transferred to Evonik; this agreement will allow METEX to continue using these patents for activities other than those related to methionine. Furthermore, the companies intend to explore the possibility of a research and development cooperation agreement on the development of biotechnologically produced amino acids. Amino acids produced by fermentation are an important pillar of Evonik's product portfolio for sustainable animal nutrition.

## Construction begins in Singapore

In a ground-breaking ceremony, Evonik marked the official start of construction of its second world-scale plant for production of the amino acid DL-methionine in Singapore. The complex will have an annual production capacity of 150,000 metric tons and is expected to become operational in 2019.

The new production complex will increase Evonik's annual capacity of DL-methionine to a total of approximately 300,000 metric tons in Asia, and to approximately 730,000 metric tons worldwide. Moreover, the new plant will produce not only methionine but also all its strategically important precursors. It should thus be possible to ensure product quality and supply security.



Ground-breaking ceremony for Evonik's second methionine complex in Singapore.

## Cooperation in 3D printing

**E**vonik and HP Inc. are intensifying their cooperation in the development of new plastic powders for 3D printing.

As the first materials manufacturer, the specialty chemicals company will place a certified product VESTOSINT® 3D Z2773 on Hewlett Packard's Open Platform program.

The new PA-12 powder from Evonik has superior mechanical properties and is FDA-com-

pliant, as the components printed on the basis of VESTOSINT® can be approved by the Food and Drug Administration for food contact. Thus the use of additive manufacturing technologies in food production equipment components which require flexibility due to limited quantities or unique, complex designs is conceivable.

## More wear comfort, less weight

**T**ogether with Evonik, Mentor Optical Limited, an eyewear manufacturer based in Hong Kong, successfully developed its new brand model Plasteel using Evonik's high performance plastic VESTAKEEP® PEEK.

VESTAKEEP® PEEK supported the creation of a lightweight and tough optical frame with a unique patented plastic rim lock design. The Eyewear weighs 9 grams, whereas traditional frames weigh as much as 23 grams. Plasteel frames' rim height can be designed to be as low as 1.6mm, while the



Plasteel Eyewear made from VESTAKEEP® PEEK.

thickness at the temple can be as thin as 0.9mm. The frames are ultra-strong and can sustain a 360 bending test without breakage, providing performance and protection against broken eyewear especially in sport activities.

## New precipitated silica plant

**E**vonik is building a production plant for precipitated silica in South Carolina (USA) to supply the tire industry. The industry needs silica for producing fuel-efficient tires with good wet grip properties. The world-scale facility with an

investment volume of around US\$120 million is to be completed in 2018.

"With the construction of the plant and the planned acquisition of the silica business of Huber, we are extending our leading market position as a silica provider," said Klaus Engel, Chairman of the Executive Board of Evonik.

The use of silica in combination with silanes enables the production of tires with significantly reduced rolling resistance that save fuel (compared to conventional car tires). Evonik is the only manufacturer to offer both components.

## Expansion for biomaterials

**I**n Birmingham (Alabama, USA) and Darmstadt (Germany), Evonik is expanding its production facilities for the production of biodegradable polymers marketed globally under the brand names RESOMER® and RESOMER® SELECT. These poly-lactic-glycolic-acid (PLGA) copolymers are primarily used to manufacture bioresorbable medical devices and controlled-release formulations for parenteral drug delivery.

The expansion will involve the construction of a new building adjacent to Evonik's existing facility in Birmingham in 2017. Besides greater production capacity, the project will also result in new production cleanrooms and a laboratory for polymer contract research projects. The Darmstadt unit capacity will also be increased with the opening of a new production line.



Evonik's laboratory in Birmingham.



The German Sustainability Award is regarded as one of the most prestigious of its kind in Europe.


## RESEARCH FOR SUSTAINABILITY

Evonik has received the German Sustainability Award in the Research category for the development of a new production process for thermoelectric generators (TEGs).

TEGs convert surplus heat into power. A team with members from Creavis, Evonik's strategic research unit, and Process Engineering has succeeded in reducing production costs for TEGs by up to 70 percent. In motor vehicles, TEGs can help relieve the load on dynamos and thus reduce fuel consumption.

Evonik was also among the top five nominees in the category of Germany's Most Sustainable Large Company 2016 because, according to the jury's citation, it has made a significant contribution to sustainable development through the development of new products and business models.





The tread surface of a tire is approximately the size of a postcard, which is sufficient to keep vehicles on the road safely.

# SAVING WHILE DRIVING

**POLYVEST® ST significantly reduces the rolling resistance of tires. For this achievement its developers were recognized with the 2016 Evonik Innovation Award.**



*Dr. Niko Haberkorn, Dr. Jürgen Herwig,  
Dr. Kai-Steffen Kramig, Dr. Caren Röben, and  
André Wehmeier*

Consumers have come to expect energy rating stickers on items such as refrigerators and washing machines. The efficiency ratings, arranged in descending order from A to G, designate appliances with increasing energy consumption. However, the system, with its seven differently colored arrows of varying lengths, is not limited to household appliances. The rating has also been applicable in a figurative sense to automotive tires ever since the EU Energy Efficiency Directive took effect in late 2012. In the case of

tires, the label indicates fuel efficiency and wet grip in separate scales, both for passenger cars and for commercial vehicles. A third criterion included in this relatively new EU label shows the rolling noise as a decibel value.

### Labels give consumers an idea of a tire model's performance

Outside of Europe there are a number of comparable classifications in Brazil, China, Japan, and South Korea; a similar system is in preparation in the United States. Experts expect additional countries to follow suit in the years to come.

The introduction of the label has given consumers a clear idea of individual tire models' impact on fuel consumption. That

is a good thing because tires, according to the French tire manufacturer Michelin, account for up to 20 percent of energy losses in an average passenger car.

According to Michelin's projections, the rolling resistance of tires is therefore the cause of an astonishing 4 percent of the global carbon dioxide emissions associated with the combustion of fossil fuels. Accordingly, lower rolling resistance means greater sustainability. Of course there are natural limits to this reduction. After all, the approximately postcard-sized contact surfaces of the four tires are the only connection of the vehicle to the road.

Tire manufacturers, and particularly large, internationally active companies, are therefore interested in offering tires with →



→ the highest energy efficiency without having to make unnecessary compromises. As the greatly simplified magic triangle of tire technology illustrates, that is not an easy endeavor. The properties of rolling resistance, wet grip, and life expectancy or abrasion resistance cannot be improved simultaneously; rather, improving one of the three properties typically has a negative effect on at least one of the others.

Fortunately, the principle is not a law of nature, but is based on experience. Michelin was able to demonstrate in 1992 that one property can be improved without causing substantial disadvantages for the other two properties. At the time, the company replaced the active filler carbon black in the treads of its “green” tires with the silica/silane system in addition to the traditional rubber system. This enabled Michelin to reduce tire rolling resistance without negatively affecting wet grip or life expectancy. Over the past two decades, this innovation has helped decrease the rolling resistance of tires by up to 30 percent.

### Green tires are a fundamental technological breakthrough

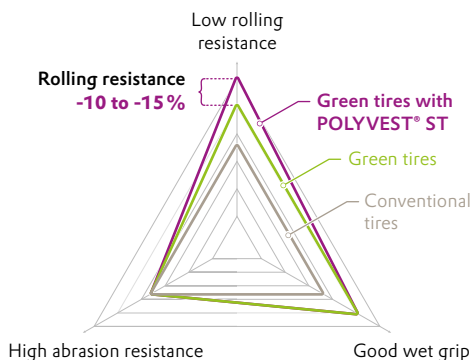
This breakthrough was not simply based on replacing a few substances, but represented a fundamental technological innovation. While rubber, which serves as a matrix material, and the filler carbon black are both nonpolar, precipitated silica is polar. Therefore it has a relatively poor interaction with rubber, and that leads to incompatibility.

A coupling reagent therefore ensures that the polar surface of the silica particles has better compatibility with the nonpolar rubber matrix. It is made of organic silanes, which react with the polar groups at the surface of the silica particles during the manufacture of the tire rubber mix. Thanks to this hydrophobic treatment, silica and rubber form a chemical bond during the subsequent vulcanization. Such silica/silane systems nowadays are the standard for

### The magic triangle of tire technology

Thanks to their lower rolling resistance, tires made with POLYVEST® ST can reduce fuel consumption by up to 2 to 3 percent.

Source: Evonik



The art in the development of energy-efficient tires consists of reducing rolling resistance without negatively affecting wet grip and life expectancy.

tires with minimal rolling resistance as well as high-level wet grip and long life expectancy. As customers embraced this development, the share of green tires in the overall tire market has increased by approximately 30 percent since 2010.

In an analysis of the global market for high-performance passenger car tires published in 2015, the testing and consulting firm Smithers Rapra came to the conclusion that the growth in this segment will continue to outpace the growth of the overall tire market. According to the report, end consumers now buy such tires for driving comfort, low rolling noise, and high fuel efficiency, while the choice of high-performance tires used to be solely driven by their size and higher permissible speeds.

Evonik is the only company worldwide to produce both silica (ULTRASIL® and AEROSIL®) as well as silanes (e.g. Si 69®, Si 266®, and Si 363™) for the rubber processing industry. However, the researchers of the specialty chemicals company were not satisfied with the progress in silica/silane systems. During a regularly held multi-unit workshop on the future of tires in 2012, an idea was suggested for further reducing rolling resistance. The proposal was this: Liquid polybutadienes produced by Evonik were already used in tires to customize other properties; could the polymers not be modified to further improve the properties of silica/silane systems? Thanks to Evonik’s competency in tire technology and polymer design, it was soon confirmed that this would be feasible. The result of the subsequent development work is now available in the form of POLYVEST® ST.

The name stands for a liquid polybutadiene, whose functionalities are comparable to silanes and which can bond with the surface of silica particles. This makes it possible to reduce the polarity of silica particles and distribute them homogeneously in the matrix. In this way, POLYVEST® ST further increases the compatibility of the silica/silane system with tire rubbers.

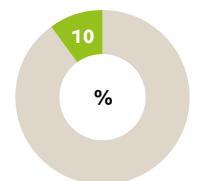
### High growth

In past years, the share of green tires in the total sales volume of tire manufacturers increased from 10 to 30 percent.

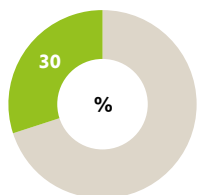
Source: Evonik

#### Market share of green tires

**2010**  
1.2 billion passenger car tires sold worldwide



**2015 (forecast)**  
1.4 billion passenger car tires sold worldwide



Evonik has demonstrated this effect in material tests. In conjunction with POLYVEST® ST, tire rolling resistance can be reduced by another ten to fifteen percent, which is the equivalent of 2 to 3 percent in fuel savings in a typical passenger car. At the same time, wet grip and abrasion resistance remain at a level comparable to formulations based on silica/silane systems without POLYVEST® ST.

Relatively little time has passed from the original idea to the finished product. The Evonik team started its preliminary studies in 2012. The polymer design phase and the subsequent production and testing of precursors in the laboratory soon made it clear that the project was heading in the right direction. Further modifications and material tests followed, and the developers were able to claim a patent for the product in 2015. Thanks to these intellectual property rights, Evonik is now able to effectively protect its know-how.

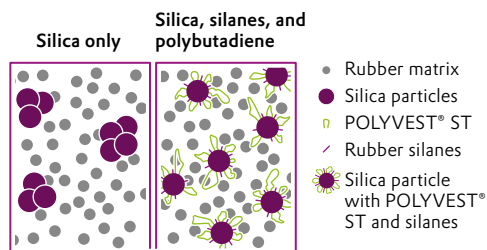
### Deep production expertise ensures quick scale-up

In the same year, the company began to ship samples to customers. This led to positive feedback within a short time. As a result, POLYVEST® ST advanced to the pilot scale to enable customers to perform additional tests. The transfer to production scale succeeded quickly because Evonik owns suitable facilities and has specific production expertise. Typically, several years pass between sampling and the production of commercially relevant volumes, so the quick pace of the development speaks for the new product.

The tests are now running in parallel, since formulations still have to be adapted to the rubber mix used by customers. Every manufacturer in the tire industry uses pro-

### Tire tread structure with POLYVEST® ST

The new polybutadiene improves the compatibility of rubber and silica, which ensures that silica particles are evenly distributed in the rubber matrix.



## Tires containing POLYVEST® ST in the tire treads will enter the market in the near future.

proprietary formulations and mixing processes that vary in specific details. Changing requirements also result from the various tire models to be used, which differ by tire size, for example.

Evonik is currently positioning POLYVEST® ST as a product for tire treads, which have the largest impact on rolling resistance. In the company's reference formulations, the additive POLYVEST® ST has a share of a few percent by weight in the material mix of the tire tread. In principle, the use of liquid polybutadiene is also conceivable in other areas of the tire, which also impact rolling resistance, although to a lesser extent.

Furthermore, the principle of POLYVEST® ST may be of interest to other markets, such as mechanical rubber goods. The liquid format of the product is another advantage, since the relevance of liquid polymers in the rubber market is growing thanks to their plasticizing effect on the mix. This allows for the partial replacement of environmentally problematic oils as plasticizers.

The market potential of the functioning polymer is also promising. However, Evonik will initially concentrate on the application in tire trends for the moment, expecting that the collaboration with multiple leading tire manufacturers will bear fruit in the near future in the form of corresponding products for the retail market.

### The experts



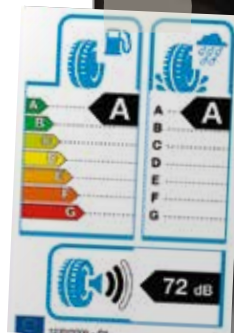
**Dr. Kai-Steffen Krannig** heads the laboratory at the Polybutadiene Competence Center of Evonik Resource Efficiency. [kai-steffen.krannig@evonik.com](mailto:kai-steffen.krannig@evonik.com)



**Dr. Niko Haberkorn** is responsible for the applied technology of liquid polybutadienes such as POLYVEST® ST in the Coating & Adhesive Resins Business Line. [niko.haberkorn@evonik.com](mailto:niko.haberkorn@evonik.com)



**André Wehmeier** leads the Rubber Technology team in the applied technology unit of the Silica Business Line. [andre.wehmeier@evonik.com](mailto:andre.wehmeier@evonik.com)



Fuel consumption, wet grip, and tire rolling noise—the EU tire label makes it easy for consumers to compare these properties.





# TEST TRACK FOR COATINGS

**A new, fully automated high-throughput system for testing coating formulations enables Evonik to cut down significantly on time spent searching for the optimal formulation. In doing so, Evonik accelerates not only its own pace of innovation, but also that of its customers.**





## “Our customers now can develop and optimize coating formulations faster.”

Ellen Reuter

developing a coating formulation, only ten curing agents, ten binders, ten pigments, and ten additives are being considered, then the number of possible combinations is already  $10^4$  or 10,000. And that doesn't even take into account variations in the relative amounts of the components.

In practice, it is impossible to cover the full range of possibilities and to test the properties of all combinations and proportions. On the other hand, the prerequisite for a systematic search for the optimal coating formulation is to investigate this range as extensively as possible at reasonable expense in terms of finances and manpower—because this is the only way of ensuring that nothing is left to chance. Evonik's coatings experts have now found a way to overcome this challenge, by developing a high-throughput system that is exactly tailored to meet the requirements for developing and formulating a coating.

### Faster testing for the perfect formulation

With this system, Evonik has improved its chances of zeroing in on the additive or specialty binder that perfectly matches the other system components and accounts for the coating's purpose (end use). This is not an easy task. Additives, for example, make up a very small percentage of the formulation, but they have a major influence on the coating's properties. They can impart a defoaming effect, prevent pigment agglomeration, and ensure that the coatings behave thixotropically—that they are easily applied but do not sag or drip on vertical surfaces while drying. Other additives can increase the scratch-resistance of coatings. Many additives are available for perfecting a formulation. The search for the optimal additive(s) is also complicated by the fact that, depending on their chemical composition, the additives can interact with other coating components.

The new system is invaluable because it allows for the systematic testing of more formulations than previously possible within a given time frame. For customers, this means they can optimize and develop coating formulations faster, saving valuable time in the market launch of new products.

The system is two meters high and occupies a 120-square-meter area in an air-conditioned room. It doses the raw materi- →

Claudia Bramlage and Ellen Reuter

**A**bout 40 million metric tons of coatings are used globally every year. These coatings protect surfaces from corrosion, impart special properties such as electrical or thermal conductivity, and increase the lifetime of consumer goods. Expectations for coatings are steadily increasing. Due to increasing complexity and regulatory pressure, customers are continuously faced with new challenges.

Formulating a coating is an intersection of art, craft, and science. In addition to the main binder component, coatings may also contain organic solvents or water, pigments and fillers, catalysts, co-solvents, and additives. For each of these components, a variety of different chemical substances may be used. The number of possible combinations of the various ingredients is enormous. If in

A track system for transporting panels and containers extends through the entire 120-square-meter HTE system.



→ als automatically and, in the first step, formulates them into coatings on the “formulating island.” In the second step, substrates—also known as panels—are coated with the formulated coatings, dried, and transported to the test island, where the properties of the formulations are characterized as soon as the coating formulation is cured. All of the steps run automatically in accordance with a precisely defined program that is reproducible at any time—and that is one strong point of the system.

### Complex steps fully automated

Formulate, coat, characterize: It sounds simple enough, but in fact the machine is tasked with performing a large number of complex steps. The system consists of 52 elements that combine to give 30 functionalities. Each functionality represents the performance of a particular task, such as applying a coating formulation on a panel. The 52 elements are linked by a track system that extends through all parts of the HTE system; on this track system, containers and panels are transported by shuttle. There are also 13 robots performing various tasks, such as loading shuttles or placing panels in the oven.

On average, 120 samples can be formulated in the system within 24 hours. While they are being applied to a panel and characterized, experiments for a new project can be initiated, hence the name High-Throughput Equipment (HTE).

The dosing and mixing of the raw materials are particular challenges for the system. For example, the viscosity of the liquid raw materials being used can vary from extremely free-flowing to so viscous that the substances must be heated before they can be dosed and filled. Moreover, certain liquids can attack the materials of containers and tools by dissolving them. Pigments and fillers in powder form can also be tricky to handle. Their bulk density and flowability varies; depending on the powder, this could complicate accurate weighing and dosing.

While a well-trained technician quickly learns how to handle these raw materials, this is not an easy task for an automated system. But the new HTE system rises to the occasion, thanks to well-developed software that allows for the setting of all the parameters required for dosing. For liquids, these parameters include pressure, temperature, and the opening times of valves. For powders, on the other hand, these parameters include the speed of the metering screw during gross dosing, the region of fine dosing, and the fine-dosing amplitude. In the master RaceLab software, developed by Evonik itself, all of the input and output data required to operate the system are collected in a single database.

Thanks to optimized engineering, the HTE system doses reliably and reproducibly. It registers any deviations from target val-

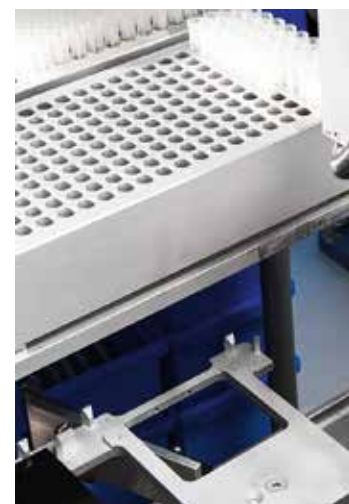
ues and saves the information. In case of anomalous results, it is then easy to trace whether irregularities occurred in the workflows.

The strengths of the system are also evident in the production and testing of pigment concentrates. Pigments must normally be ground by grinding media in a highly time-consuming process. The HTE system has a special mixer for this purpose, in which double rotation of the mixing cup ensures significantly faster grinding and dispersion.

Moreover, a specially provided air cooler prevents excessively high heat generation, which could destroy the raw materials. The subsequent separation of the grinding beads from the sometimes highly viscous mixtures, as presently performed in the laboratory, is highly labor-intensive; in the HTE system, this is done by a centrifuge. A specially developed filter adapter allows the coating material to pass through while retaining the grinding beads; the necessary movements are performed by a robot.

### Objective parameter instead of a subjective test

To evaluate the storage stability of a pigment concentrate in the laboratory, a visual inspection and the use of a spatula reveal whether a sediment has been formed. Transferring the corresponding optical and tactile capabilities to a machine would have required enormous expenditure and effort. The developer of the HTE system found another solution: A measuring head determines the mechanical resistance it encounters when lowered into the sample. In this way the somewhat subjective human assessment is replaced by an objective parameter.



# 120

**samples a day** can be formulated and tested by the new high-throughput system.

Formulations from various projects.





Precise and cautious: A robot designed for this unique purpose draws the coating into a pipette, applies coating droplets onto a panel, and uses a doctor blade to produce a precisely defined coating thickness.

Another step that poses a challenge to the fully automated system is the application of a coating formulation using a doctor blade. The panel must not slip during application, the quantity of the coating must correspond to the desired coating thickness, and the surrounding area must not be soiled, because that would contaminate the following panel. These tasks are assumed by a robot specially designed for this purpose. Panel after panel, the robot applies exactly the same quantity of coating in exactly the same thickness and cleans the doctor blade in various wash solutions before repeating the procedure.

The HTE system also offers advantages in the rub-out test for assessing pigment stabilization. In the laboratory, this is performed by rubbing the freshly applied coating layer with a finger; if the pigments are not sufficiently stabilized, the shear forces applied result in a visible color change of the rubbed surface. The skill in this test lies in not displacing material while rubbing and not causing gaps to occur in the coating layer. The HTE system replaces this subjective test with a precisely coordinated control system whose parameters are individually adjustable for any coating system via the software.

Altogether, the high-throughput system reduces the burden on laboratory staff by taking over onerous routine tasks, leaving employees free to concentrate on planning experiments and analyzing the data.

### Flexible use around the clock

RaceLab allows all workflows to be planned in detail. No fewer than 40 different work steps can be precisely defined with up to 600 parameters in the HTE system. This allows Evonik to freely combine individual steps into a workflow so as to satisfy the most diverse customer requirements. The HTE system can therefore be used very flexibly—and around the clock.

### The strengths of the HTE system

- 1 Operates **fully automatically**, provides reproducible results, can be used flexibly
- 2 Formulates coatings from a wide variety of different **raw materials**
- 3 Characterizes the **fluid formulations** prior to application
- 4 Coats the panels **precisely** and dries or cures the coating
- 5 **Characterizes** the finished coatings
- 6 Produces a continuously growing **data pool** as a basis for future analyses via data mining

In addition, RaceLab also records all measured data and allows analysis of complex test series; this is a huge advantage because the HTE system produces much more data in a significantly shorter time than is currently the case in the laboratory. A constantly growing data pool is generated, which can be analyzed in the future by data mining methods.

It may even be possible to reduce the number of experiments necessary. Using the data already available, computational intelligence would extrapolate what might be found within the scope of the options or, at the least, indicate where more detailed investigation would be worthwhile. In this way customers could further speed up the innovation process with the help of Evonik and the HTE system.

### The experts



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**Claudia Bramlage** and **Ellen Reuter** are responsible for the operation of the new HTE system in Innovation Management of the Resource Efficiency Segment.



DR. STEPHANIE WOHLGEMUTH

# The strategy behind chemistry

Dr. Stephanie Wohlgemuth actually intended to stay in academics after earning her Ph.D. Now, however, she works in Evonik Corporate Strategy, where she faces new challenges every day.

**D**iversity has always been part of Dr. Stephanie Wohlgemuth's life. Born in Saudi Arabia to a German father and an Indonesian mother, she had already lived in five different countries by the time she finished her Ph.D. in chemistry in Potsdam. "My father worked for a German automaker and had to travel a lot for his job. We went along wherever they sent him, so we were constantly exposed to new people and cultures," Wohlgemuth explains. "I didn't want to give up that diversity—even once I started my career."

That's why the chemist stayed in constant contact with international researchers while she pursued her doctorate at the Max Planck Institute of Colloids and Interfaces, and regularly participated in conferences and workshops—originally with the aim of pursuing an academic career at a university in the United States. "I couldn't really imagine chemistry in industry being that interesting," says Wohlgemuth. Creavis President Prof. Stefan Buchholz was able to change her mind at a conference on sustainable chemistry. "We started talking and I was immediately excited about how many disciplines and types of projects are represented at Evonik," the 30-year-old recalls. "Some 4,000 products and operations in over 100 countries all over the world—that impressed me."

Shortly afterward in 2013, she started her career as part of a trainee program at Creavis, the strategic innovation unit of Evonik.

"It was a perfect entry for me," Wohlgemuth says. A large variety of projects gave her the opportunity to meet many new colleagues while collaborating with Evonik's segments at the interface between business and research geared toward long-term goals. Among others things, she developed the concept for the first Science-to-Business workshop, assumed responsibilities at the Composites Project House and in Strategic Controlling, and supported the Creavis 3.0 Project, which aimed to continue development of the strategic innovation unit.

## Making strategic decisions

"I learned how interesting it is to make strategic decisions," says Wohlgemuth. "A key question at Creavis was always what activities we wanted to invest in for the future. What will keep us competitive and advance our customers' aims?" This was no easy task: Decisions had to be questioned over and over and adapted to the fast-paced environment of the market. "Each day was different," Wohlgemuth recalls. "Working on such a wide range of topics with creative and highly talented colleagues really motivated and inspired me."

After spending time in Taiwan for a project, she worked as a business analyst for Creavis, providing market-related support for strategic research projects. Due to the

strong collaboration with Evonik segments, taking a job there seemed a likely next step for her. However, another option opened up for the chemist: transferring to Corporate Strategy, a unit that advises the Executive Board on the Group's overarching strategic orientation and addresses question such as, How should we position the portfolio in the long term? Do segment activities fit in with the company's overall strategy? What do we need to do to position Evonik for sustainable success?

Within this corporate division, Wohlgemuth works as a strategy consultant for the

Dr. Stephanie Wohlgemuth in the corporate headquarters of Evonik in Essen.



**"My work has to stay as exciting and versatile as it is now."**



Corporate Structure & Functional Strategy department led by Peter Friesenhahn, where she focuses on strategic activities of Technology & Infrastructure GmbH (TI). “TI bundles infrastructure and technology services, and has around 8,000 employees making a fundamental contribution to the company’s success,” Wohlgemuth points out. “As the backbone of the operational chemistry segments, TI provides reliable services and innovative technologies.”

### Maintaining a dialogue

As a contact person and an interface to the Executive Board, Wohlgemuth regularly updates the board on developments within TI, provides assessments, and offers recommendations. The strategy consultant also plays a check-and-balance role with

respect to Technology & Infrastructure, i.e. she stays in regular contact with her colleagues and supports the dialogue with the Executive Board.

This includes TI’s annual “Strategy Dialogue.” At this event, segment representatives meet with the Executive Board to discuss how their services can be geared more effectively toward the needs of customers and how TI can support the company’s overall success. The key challenge for the service units is to continuously develop and improve their competitiveness and efficiency. Digitalization is one of the strategic topics discussed during this dialogue. An example applicable to technical services is predictive maintenance. This involves making intelligent use of plant and equipment data as a basis for health assessments,

which give operators the ability to identify and eliminate anomalies that could lead to unplanned plant failures over the short or long term. “That increases plant availability, which, in turn, reduces costs and—most importantly—raises customer satisfaction,” Wohlgemuth explains.

When she looks back at her views in graduate school, the chemist can’t help but smile to herself. “Now I know that chemistry in industry is never boring,” says Wohlgemuth. “There are so many disciplines and so much work to do—the variety of new opportunities never runs out.” She doesn’t know where her path will take her, but she could well imagine working at one of Evonik’s sites abroad. One thing she knows for sure, however: “My work has to stay as exciting and versatile as it is now.” ●



The DNA double helix: Basis for the continuity and variability of all life forms.



## DELVING INTO OUR DNA

# Measuring the genes

Human interference with the gene pool of flora and fauna is nothing new. As far back as 10,000 years ago we domesticated aurochs, breeding these wild animals into various varieties of domestic cattle. Through a process of selection and crossbreeding, we transformed wild wheat into higher-yielding agricultural crops and turned wolves into pugs—but for much of that time, we had no clear understanding of what was going on in the crossbreeding process. That understanding did not emerge until the modern science of genomics came along. The DNA double helix was discovered in 1953, the first full genetic sequence of a eukaryotic organelle was published in 1981, and the human genome was not fully mapped until 2003.

Hundreds of millions of euros were poured into this basic research, producing several Nobel Prize winners and making the field ripe for a revolution that would transform humankind: selective modification of the genome. The first fruits of this work have been rapidly falling prices for gene sequencing. While a human genome cost roughly US\$10 million to sequence in 2007, it can now be done for US\$1,000. And over the next five to ten years, that figure could even

fall to below US\$10. The potential advantage of this development is that by comparing individual blueprints of life researchers hope to gain insight into how genetic dispositions play out.

But that's not all: The discovery of the CRISPR/Cas method in 2012 has provided a tool for selectively modifying the genetic makeup of plants and animals. These so-called genetic scissors offer an easy, precise, and cost-effective way of modifying DNA and RNA, opening the door to new kinds of medicines, to the healing of genetic disorders, and to the development of synthetic organisms.

The Corporate Foresight team from Creavis, Evonik's strategic innovation unit, focuses on the profound changes brought by the age of genomics as part of its GameChanger focus topic. The team's goal is to identify the opportunities for innovation these changes hold for Evonik, as well as the risks they pose. One thing, however, is already clear: Genomics has enormous disruptive potential. Over the coming years we will see where its boundaries are and where boundaries need to be drawn—development in the field will have to go hand in hand with an intense ethics debate.





Combining foundational science and application to produce first-class research: Prof. Dr. Robert Franke.

# A RESEARCHER AMONG RESEARCHERS

**Conducting first-class research with a limited budget? Professor Dr. Robert Franke, head of hydroformylation research at Evonik, has mastered this art. His expertise in combining internal and external competencies to generate added value was recognized with the Group's 2016 CIO Award for Best Open Innovator.**

**R**esearch is a people business," says Prof. Dr. Robert Franke. "It depends heavily on the persons involved." Industrial and academic researchers must be equals in scientific discussions to enable their successful collaboration as partners. Franke's experience has been that human factors also come into play for optimal motivation, engagement, and effectiveness.

"You can't accomplish much with a project manager attitude," says the chemist, who has been responsible for hydroformylation research in the Performance Materials Segment of Evonik since 2009.

That also requires major personal commitment. The volume of scientific publications that must be monitored and in part reviewed already goes beyond the scope of a normal workday. In Franke's area of responsibility, this includes as many as 100 to 200 publications per year.

But precisely these publications play a key role. "As a company, we consider a cooperative project successful if it helps us intelligently shape our chemical business. In contrast, for our partners, success means publications in prestigious journals," says Franke. In his mind, accepting and supporting this effort "makes Evonik an attractive industrial partner." Franke, who

was recently recognized for his achievements with the 2016 Chief Innovation Officer (CIO) Award, currently holds the Evonik record for publications with universities in leading research journals.

Evonik entered the field of hydroformylation research about twenty years ago, decades later than major competitors. As one of the most important industrial applications of homogeneous catalysis, the reaction is used to generate aldehydes from olefins and synthesis gas, which are precursors of products such as plasticizer alcohols. Annually, hydroformylation is used to produce more than 10 million metric tons of products, typically in huge facilities with capac-

## “For our partners, success means publications in prestigious journals. Accepting this makes Evonik an attractive industrial partner.”

Prof. Dr. Robert Franke

ities of several hundred thousand tons per year. Evonik is the largest manufacturer of C9/C10 plasticizer alcohols in Europe.

“Today Evonik undertakes hydroformylation exclusively through the use of unconventional proprietary methods which allow us to play in the top league in scientific terms,” says Franke. Long-term research partners include the Leibniz Institute for Catalysis (LIKAT), Rostock, under the leadership of Prof. Dr. Matthias Beller, Prof. Dr. Dieter Vogt of the University of Edinburgh, Prof. Dr. Siegfried R. Waldvogel of the Johannes Gutenberg University, Mainz, as well as Prof. Dr. Peter Wasserscheid and Dr. Marco Haumann of the Friedrich Alexander University, Erlangen-Nuremberg. Many exploratory research projects were only feasible thanks to public funding.

That paid off for Evonik, explains Franke: “We developed scientific foundations in projects such as Nano or Multi-phase. We then worked internally to come up with the corresponding production processes.” For example, Nano became the basis of the nano-filtration technology of the Performance Intermediates Business Line, while Multi-phase established the foundation of a new test reactor, in which Evonik currently studies potential process improvements based on modified reaction conditions. Three major research projects are currently under way in the area of hydroformylation.

### Further reading on the subject

The involvement in many internal and external research activities inspired another project of Franke’s. Together with Prof. Dr. Armin Börner, Professor of Organic Chemistry at Rostock University and head of hydrogenations and hydroformylation at LIKAT, he has written a two-volume monograph entitled “Hydroformylation.” The book, published in 2016, is intended to bridge the gap between academic research and industrial application. The last monograph on the subject appeared in 2000.

Franke has therefore firmly established himself in the area of hydroformylation, although he did not intend to “dig deeply” when he took over the management of process development and the technical center for hydroformylation research in Marl in 2008. A passionate researcher, he became interested in the field of theoretical chemistry as a student at Ruhr University Bochum because he was fascinated by this “foundational discipline with its strong mathematical focus,” and enjoyed learning from

### Research network

# 109

**partners**—universities, research institutes, and companies—make up the Evonik Hydroformylation Network.

# >100

**scientific publications** have been co-authored by Prof. Dr. Robert Franke.

Prof. Dr. Werner Kutzelnigg, who taught the subject.

Franke also took courses in industrial chemistry because he was certain that he wanted to work in the industry and find specific ways to apply scientific insights. There was also a prominent researcher in industrial chemistry at Bochum University: Prof. Dr. Manfred Baerns. “Both researchers were important role models at the university,” says Franke.

Although it did not help his job opportunities in the industry at the time, Franke decided to write his graduate thesis and later on, his doctoral dissertation with Prof. Kutzelnigg. He describes the topic of his doctoral research as “pure foundational research with no practical application”—the calculation of relativistic corrections of molecules with the direct perturbation theory. His work focused on the calculation of molecular properties with extreme accuracy, which required bringing together quantum mechanics and relativity theory, a challenge that remains partially unresolved to this day.

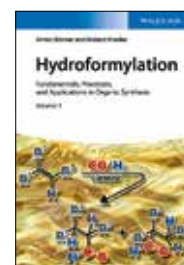
### Fascination over career planning

After Franke had completed his doctorate, the labor market once again experienced a shortage of jobs for chemists. Kutzelnigg’s offer to qualify for a professorship in the department came at the right moment. “Actually, you’re not supposed to do that; it doesn’t look good on your resume,” says Franke, “but I found it hard to escape the fascination of the field.” Then, the almost unthinkable happened: The Process Technology unit of the former Hüls AG was looking for a theoretical chemist with a technical background—a qualification that doesn’t actually exist. And so began Franke’s career in what would later become the Evonik Group, with the establishment of a laboratory for computational chemistry. His favorite assignment within the Group has been the three years he spent in the Process Intensification Project House, which allowed him to link theoretical and industrial chemistry and to improve processes by means of unconventional measures.

His current position brings all of his passions for basic science and application, research, and teaching together. Franke received his professorship in theoretical chemistry in 2002 at Bochum University and has been teaching there since, first as a lecturer and then as an adjunct professor since 2011. In 2015, he received an invitation to teach at Münster University, where he now lectures on research strategies. This gives him the perfect opportunity to reflect on his main task as Director of Innovation Hydroformylation—and to shape the next generation of industrial researchers. ●



Innovation Award for an individual achievement: the CIO Award.



**Armin Börner, Robert Franke:** **Hydroformylation: Fundamentals, Processes, and Applications in Organic Synthesis**, Wiley-VCH, Weinheim 2016.

ISBN:  
978-3-527-33552-7



# UNDER A FOREIGN FLAG

**In Tippecanoe Evonik produces pharmaceutical products for people and animals. Yet not one of them is an Evonik product.**

Evonik's Tippecanoe site in the US is a success story with regard to contract manufacturing of pharmaceutical active ingredients.

**T**his site is Evonik through and through: gold standard in the laboratories, in production, and in all other locations—with efficient, state-of-the-art production and the highest safety standards throughout. And yet it is not a typical Evonik site. None of the Group's products have ever been produced here. The Tippecanoe site in Lafayette in the US State of Indiana operates as a CMO, a contract manufacturing organization for the pharma industry. The site produces complex pharmaceutical actives on behalf of its customers, applying the chemical development and manufacturing competencies and know-how of Evonik, one of the world's leading specialty chemical companies.

Evonik acquired the plant in the state of Indiana from Eli Lilly, a major drug manufacturer, in 2010. Eli Lilly changed from being the owner of the site to its first customer—and remains an important customer to the present day. Over the past six years, the number of customers has risen from one to 20 and the site's flexibility and agility were brought up to international standards. The site is part of the Health Care Business Line in Evonik's Nutrition & Care Segment.

Clive Whiteside, Vice President and manager of the Tippecanoe site since 2013, describes Evonik's current strengths in the CMO market as follows: "We have a great deal more to offer than other providers: We are technically more diverse, more international, and more financially sound than other CMOs." This is due to the fact that Evonik is simply not your typical company that manufactures on behalf of other companies. "Our strength is that Evonik has ex-

**20**

**pharmaceutical companies** have the active ingredients for their medicines produced in Tippecanoe.

**"We have a responsibility to the people who are dependent on the medicines."**

*Todd T. Wetli, head of quality in Tippecanoe*

perts for everything. Our customers never need to be concerned that we are unable to cope with a new aspect of an order. There are always experts in the company who can provide assistance. This sets us apart from the competition."

### Highest possible quality is key

Many factors are important in this business—and one is indispensable: quality. Quality in products. Quality in production. Quality in safety. Anything but the highest possible standard would be inadequate. This quality standard is continuously monitored by independent agencies. Not only does the strict U.S. Food and Drug Administration (FDA) inspect the site at regular intervals, but other national and international regulatory authorities also come to the plant to monitor compliance with the pertinent regulations.

The person responsible for this on the site management team is Todd T. Wetli, head of quality in Tippecanoe. "We have a well-equipped and experienced team that works exclusively in quality assurance and we take pride in our excellent track record," said Wetli. He also explained why so much time and effort goes into quality assurance: "We have a responsibility to the people who are dependent on the medicines—and this starts in production."

The ability to reliably scale up the production of complex molecules to industrial scale is one of Evonik's biggest assets in this hard-fought market. A number of its customers are essentially research and development units which have the ability to produce an innovative compound in the laboratory. They then draw on Evonik's expertise for the transformation to industrial scale.

### Reliability creates confidence

Bryce A. Hufford, director of small molecule manufacturing, explained: "We collaborate with big pharma, but also with smaller research companies." A process is developed for each molecule—from the very beginning. "When a customer comes and asks us to produce a special molecule for them," said Hufford, "we strive to provide peace of mind that we will deliver the project on time and with the precise specifications that they, and ultimately their patients, require."

Small-molecule compounds include high-potency anti-cancer pharmaceutical actives. Site manager Clive Whiteside explains the responsibility that arises from →





With the help of state-of-the-art analytics it is ensured that active ingredients produced in Tippecanoe meet the respective specifications.



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→ this: “We produce cancer drugs that keep people alive day after day. In one case, we are actually the only producer of the compound at the present time. This means we must never ever have any trouble producing it.”

While the business with small-molecule compounds has been an attractive growth area for Tippecanoe for a number of years, fermentation is a business with a long history. For more than 50 years, production via fermentation has been performed at the site, with all processes adhering to the principles of Good Manufacturing Practices (GMP). Some 1,000 fermentations are performed every year. The largest fermenters have a capacity of 250 cubic meters.

### Protecting customers’ know-how is a top priority

Although the managers in Tippecanoe are assertive about the achievements of their site, they clam up when asked about the names and products of their customers. Only Eli Lilly is mentioned, because the company, as the previous owner, has remained loyal to the site and has historically had its anti-cancer drug Gemzar, among other products, produced there. “All our staff members understand our obligation to protect our customers’ confidential information and know-how,” says Clive Whiteside. “The products we produce here and the

### Data and facts

**Location:** Lafayette, Indiana (USA)

**Workforce:** around 600

**Total area:** 9.5 square kilometers (factory premises: 1 square kilometer; farmland: 4.5 square kilometers; nature reserve: 4 square kilometers)

**Tippecanoe** is the name of the county in which the plant is located



production methods we use are at the cutting edge of research and a key component of high-value drug franchises.”

Evonik protects the knowledge of its customers just as carefully as its own. There is a permanent team assigned to every project. This close relationship with clients is essential for success. Whiteside: “Pharma companies are extremely conservative. If you do a good job, they will trust you and won’t look for new partners.” And there is a great deal of trust. As a rule of thumb, the more complicated a project, the more likely it is that Evonik will be awarded the contract. ●

The Tippecanoe site has been exclusively producing pharmaceutical products since 2000 and since 2010 under the Evonik brand.

## “ ANYTHING BUT THE HIGHEST POSSIBLE STANDARD WOULD BE INADEQUATE ”

Interview with Dr. Andreas Meudt, Vice President of the Exclusive Synthesis Product Line in the Health Care Business Line.



**“The trust our customers place in us is a very central pillar of our success.”**

*Dr. Andreas Meudt*

**The same holds true almost anywhere in the world: Where Evonik is on the label, Evonik is in the product. In Tippecanoe Evonik produces on behalf of third parties. Is this not a contradiction in itself?**

Our Tippecanoe site produces active ingredients and precursors for pharma companies around the world. It is true that we produce the very products that customers want to have from us, but the added value that Evonik provides to customers goes far beyond the active ingredient in question. Globally, the name Evonik is synonymous with superior chemical competencies, top quality, absolute delivery reliability, and 100 percent dependability. In this respect, Evonik is “in” all of our Tippecanoe products, and this is also the main reason why we are currently seeing such strong growth at the site.

**Why is Evonik not active in the market with its own active ingredients?**

In Tippecanoe, we focus on ingredients which are used by our customers as actives in high-value innovative drug products. These medicines are approved by regulators after undergoing stringent testing in human clinical trials to assess their safety and efficacy. These test programs are very costly—a complete drug approval carries an average cost of approximately US\$1 billion—and have a low success rate. So while the development of drug products is very profitable when successful, it carries a much higher risk and is therefore a completely different business from the production of active ingredients for other customers. Evonik decided for good reasons not to be a pharma company. This clear message to the market helps us establish strong relationships with our customers based on trust that we will not compete with them.

**What role does Tippecanoe play in the collaboration between the Health Care sites?**

Tippecanoe is very well connected with other sites in the Health Care site net-

work. In new projects, Evonik and the customer usually decide jointly which Evonik site is best on the basis of the expertise and facilities available. There is even a series of products that are produced partly in Tippecanoe and partly at other sites, such as Hanau. This is because certain technologies are established only in Tippecanoe and others are established solely or better at other sites. We also see more and more transfers of people between sites, transforming our organization into a truly international team. After only a few years with Evonik, Tippecanoe has become a very important element of the Health Care organization.

**The protection of know-how in the interest of the customers is a top priority. Does Evonik still benefit from the experience gained in Tippecanoe?**

The trust our customers place in us is a very central pillar of our success. It is for precisely this reason that increasing numbers of customers are turning their backs on Asian low-cost producers and returning to dependable providers like Evonik that guarantee quality and reliability in every respect—including the all-important protection of the customer’s know-how. The long-term preferred relationships that arise as a result are the basis for the joint success of the pharma

customer and Evonik. In any project we take on, we always clarify early what is our know-how and what is the customer’s so that we protect and grow our know-how with every project. By working closely with our customers, we also get strong insights into their needs and ambitions going forward and this allows us to detect and implement new trends in the industry.

**What is the Exclusive Synthesis Product Line working on at the moment?**

We are currently working on four core technologies—for example, high-potency active pharmaceutical ingredients (HPAPIs) against cancer and the transfer of unique Evonik expertise in continuous processes to the pharma world. Customers are particularly interested in these topics.

**Are there connecting points between the CMO business and the remaining production?**

The connection points are clearly scale-up and manufacturing excellence and our ability to bring non-pharma processes and products to pharma standards. In this context, we have joint activities with other businesses. Time and again this leads to the generation of new ideas for our customers, such as ultra-pure polyethylene glycols, which Evonik has been producing for non-pharma applications for quite some time and that we are now bringing to the pharmaceutical sector. Another example is the transfer of continuous processes to our CMO business.



**Joachim Müller-Jung**

(53) has headed the Nature and Science department of the *Frankfurter Allgemeine Zeitung* newspaper since 2003. Müller-Jung studied biology at the universities of Heidelberg and Cologne (Germany). He obtained his degree after a research stay in the tropical rainforest of Madagascar and after writing his thesis about the island's reptilian fauna. During his studies, he pursued his interests in scientific journalism by reporting for news agencies, newspapers, and as a freelance journalist for the *Kölnische Rundschau*. After a two-year traineeship at that newspaper he joined the *Frankfurter Allgemeine Zeitung* in 1995.

## WHAT I HOPE FOR FROM SCIENCE

# Joachim Müller–Jung

## INTERVENTION

Our information load is growing day by day—that is wonderful news. It could go on like this forever. But progress toward the better cannot be taken for granted in this exclusively human endeavor. And it won't come for free for society, even though tax money is flowing abundantly. Science could demonstrate true greatness by accepting the social responsibility that it itself claims at the internal level. That's why I am calling for the community to open up its well-trodden paths of conversation to engage more in non-typical, non-scientific knowledge. Specialists cannot be indifferent to ethical progress. But university curricula still reflect this view.

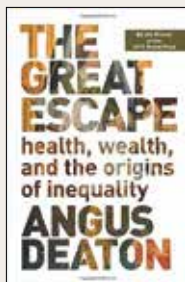
All progress comes at a cost—this holds true for science but even more so for its “difficult offshoot,” as German-born philosopher Hans Jonas describes technology. Both are a step away from triggering radical cultural change in an extremely short period of time. The power over data, genes, and minds—subjecting them to economic pressure at the same time—will cause revolutionary change. But this is unsettling society, which is the electorate in our sphere. Now, in the interest of our own protection, it is time to overcome isolation. Knowledge is democracy's cure against populists and conspirators.

It does not belong in the hands of only a small elite.



## NONFICTION BOOKS

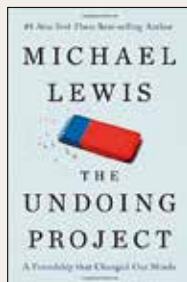
on inequality, decision limits, and the mind of the octopus.



### Why progress creates inequality

**H**ealthy, wealthy, and wise? Princeton professor Angus Deaton questions the saying that suggests that wealth, health, and wisdom occur simultaneously. In 2015, Deaton—a economist from Scotland—was awarded the Nobel Memorial Prize in Economic Sciences for his research on the interrelation of consumption and prosperity. On average, people are healthier, wealthier, and live longer today than before. Yet inequalities between people and nations are steadily increasing. Deaton describes what is necessary to make the global economy fairer and turn it into a driver for a better world.

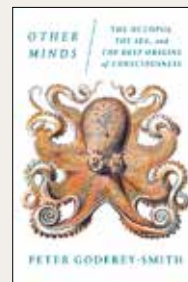
**Angus Deaton:**  
**The Great Escape: Health, Wealth, and the Origins of Inequality**  
Princeton University Press 2015



### Why your gut feeling is often wrong

**I**n the 1970s, Israeli psychologists Daniel Kahneman and Amos Tversky wrote a series of breath-taking studies on how we make decisions. Their Prospect Theory—for which Kahneman later received the Nobel Prize in Economic Sciences—shows that we cannot trust our intuition when making decisions in unknown situations. The resultant behavioral economics revolutionized survey research, among others. The book by the financial journalist Michael Lewis tells the story of the friendship of two exceptional men who jointly changed the world.

**Michael Lewis:**  
**The Undoing Project. A Friendship That Changed Our Minds**  
W.W. Norton & Company,  
New York 2016



### What goes on in the mind of an octopus

**W**hy conquer cosmic worlds to meet other forms of intelligence? According to the philosopher Peter Godfrey-Smith, instead you can just come eye to eye with an octopus. Its eye looks similar to a human eye. However, the largest part of the brain of an octopus is located in its eight tentacles. The animals are intelligent, playful, and social. They can remember and plan things, all of this without language. According to the author, the mind was first developed in the ocean and to research it could also provide incentives for the topic of artificial intelligence.

**Peter Godfrey-Smith:**  
**Other Minds. The Octopus, the Sea, and the Deep Origins of Consciousness**  
Farrar, Straus and Giroux,  
New York 2016



### THE COVER #58

Chickens will probably never eat probiotic yogurt. But probiotics could be a building block for reducing the use of antibiotic growth promoters in poultry husbandry. Evonik and its partners are developing a model that simulates the gut of a chicken to study the effect of probiotics.

### Masthead

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**\* ...HOW EVONIK PLANS TO BOOST HEALTH IN THE POULTRY PEN**