

ELEMENTS

Research. Knowledge. The future.



Food for Future

3/2019

How the Human Race Can Have Sustainable and Healthy Nutrition in the Future

Digitalization: Smart Technologies in the Chicken Coop → p. 16

Dietary Supplements: Effective Support for the Human Body → p. 38

Protein

A **protein** is a macromolecule built up out of amino acids. As the basic components of cells, proteins perform a multitude of essential tasks in the human body. For example, they make cell movement possible, transport substances, and influence chemical reactions. Human beings cannot produce proteins without a supply of the appropriate nutrients. They must ingest proteins through foods such as eggs, dairy products, meat, fish, and legumes. An adult's daily protein requirement is approximately 0.8 grams per kilogram of body weight.

Amino acid An organic compound that includes at least one carboxyl group and one amino group

Macromolecule A large molecule with a high mass consisting of many components



DEAR READERS,

“Food and drink hold body and soul together,” my father used to say as we sat down for dinner. I’ve forgotten many details from my childhood, but I do remember this sentence, as well as the serious look on my father’s face when he quoted it. I’m sure that back then I had no clear idea of what the phrase “body and soul” really means. But one thing I did understand, even as a child, was that if you eat good food and have enough to drink, you’ll be very well off.

For my parents and grandparents, good food meant potatoes, vegetables, and meat: roast beef, chicken legs, breast of duck. In the morning and evening we had sausage sandwiches, and in the summer we grilled frankfurters and pork belly. Many people live this way, and they feel that they’re very well off. But is that an illusion?

Eating too much meat is unhealthy—that’s what I hear from many sources. Our resources are limited. Less is more. After all, there’s a reason why the “Sunday roast” was only served on Sunday. I admit that for a long time I didn’t want to hear any of that. I didn’t try to find out how much water, grain, and land was needed to produce my small T-bone steak or my crispy roast.

But the three months of research I conducted for this issue have changed my perspective. In the future I’m going to eat more moderately and occasionally replace sausages with fish, partly because of the omega-3 issue. And I’ll eat my steak more mindfully, grateful that I can afford this luxury.

To make sure this will still be possible for many people in the future, we need to rethink the ways we produce and consume food. This issue addresses the question of how we can succeed in doing that as sustainably as possible. It talks about salmon and chicken, blueberries, and the question of how research and industry can contribute to this effort.

I wish you a thought-provoking reading experience!

Matthias Ruch
Editor in Chief

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Blueberries are the raw material of the dietary supplement MEDOX®

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In the digitalized grow out house, precise data analysis ensures that chicks grow up healthy—and supply nutritious meat



A SPARKLING SOLUTION

Why do tiny bubbles rise up when we drop an effervescent tablet into a glass of water? Answer: Probably because it contains potassium bicarbonate—a potassium compound that releases carbonic acid in the water. Even more important than the fizz is the health-promoting effect of potassium. The World Health Organization recommends that we consume much more potassium instead of sodium. A potassium-rich diet reduces blood pressure and thus the risk of a stroke. The potassium compounds that Evonik develops for the food industry don't just form refreshing bubbles—they also lay the foundation for healthy nutrition.



A LOOK AROUND THE WORLD

Innovations from science and research

Creepy Crawlies against Cancer

A study from Italy demonstrates that insects have health-promoting properties

Around two billion people worldwide regularly have insects on the menu. Insects are even gaining in importance in Western countries as an alternative source of protein. Scientists at Teramo University in Italy are now advocating that people eat crickets, caterpillars, and grasshoppers. They have found out that the regular consumption of insects can protect against cancer because the creatures contain large amounts of the vitamins A, C, and E. These vitamins



are antioxidants that shield the body against free radicals and help prevent pathological mutations in cells. According to the study, insects contain a lot more cancer-inhibiting compounds than orange juice and olive oil. Herbivorous species such as grasshoppers and silkworms are particularly rich in antioxidants. Besides traps for free radicals, insects also contain other valuable nutrients such as protein, unsaturated fatty acids, and dietary fiber.



PEOPLE & VISION

“Our benchmark is meat and the nutrients and proteins it contains”

THE MAN

Mazen Rizk studied molecular biology in Lebanon. He moved to Germany nine years ago to earn a doctorate at the Hamburg University of Technology. For his doctoral dissertation, Rizk was already experimenting with cells. At that time, he was interested in enzymes for the production of biofuels. After obtaining his doctorate, Rizk worked in the research department of a food company that produces yeast extracts that are intended to give products meaty taste. Rizk still studies fungus cells every day. However, he no longer does this as an employee, but as the founder and CEO of MushLabs.

THE VISION

Together with his team at MushLabs, Rizk is working on developing a healthy and environmentally friendly meat substitute. In the company’s lab, researchers are feeding fungus cells different carbohydrates and proteins under a variety of temperatures and pH values in order to replicate the taste and nutritional content of meat as much as possible. Rizk uses as few additives for this purpose as he can. Although the project is still in development, MushLabs plans to launch the first dishes on the market next year.

Safety Chain

How blockchain makes food safer

Everyone's talking about blockchain—even in the food industry. Numerous pilot projects have shown that this data technology can make it easier to trace food and improve food safety. For example, the IT company IBM has developed the Food Trust program, which the US retail chain Walmart is already using in a test to trace the path of salads, mangoes, and

pork. Systems like this can quickly discover sources of contamination, for example, and enable the affected products to be taken off the shelves. Farmers could also benefit from blockchains, which would enable them to prove unambiguously to consumers that the way they raise livestock takes the animals' welfare into account.

LESS PHOSPHATE, MORE PROBLEMS

The oceans contain less phosphate than was previously assumed, according to a group of researchers headed by Mike Lomas from the Bigelow Laboratory for Ocean Sciences in Maine (USA). Phosphate is an essential nutrient for every living organism on Earth. The low phosphate content is especially problematic for algae, because climate change is reducing the amount of nutrients in the world's oceans as it is. On the basis of data collected over the past 20 years, Lomas and his team are recording every change, no matter how small. The researchers want to use the new findings to better forecast the effects that climate change will have on oceans.

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PERCENT of India's inhabitants do **not eat meat**. That makes this South Asian country the world leader for a meat-free diet. A key reason for this is that India's biggest religions, Hinduism and Islam, have strict food regulations.

GOOD QUESTION



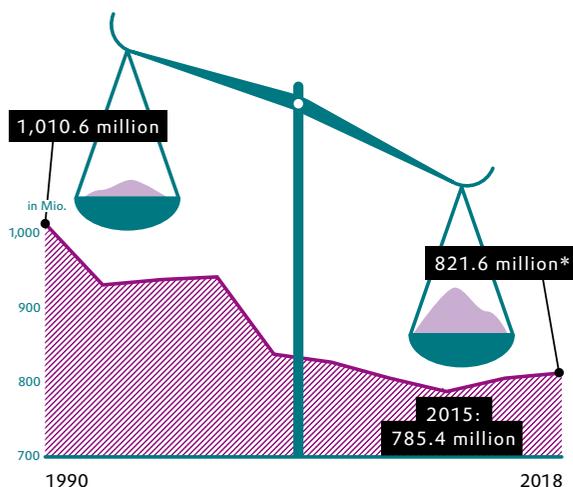
“Mr Hunter, when will our steaks be coming out of a 3D printer?”

In one or two years, according to Nova Meat, a Spanish company that is developing a 3D-printed plant-based meat product for future commercial production. It envisages restaurants using rented 3D printers and Nespresso-style capsules to print steaks just prior to cooking and serving, and it claims that the product's texture will be very meaty. So far, the 3D printing of food has lagged behind expectations. Many factors must be considered. Does the raw mixture have the right rheology? How long does it stay fresh? How can the printer be kept free from microbiological contamination? Today 3D-printed foodstuffs, such as cake decorations, are still niche products, but the growing popularity of alternative meat products could lead to a commercial breakthrough for 3D printing. The advantage of this technology is its ability to produce food on demand, thus enabling personalized nutrition—and reducing food waste.

Tony Hunter is a global food futurist from Australia. He advises companies that are assessing and implementing new food technologies

THAT'S BETTER

Fighting Hunger



More than one billion people were considered undernourished in the early 1990s. This figure dropped to around 200 million over the next 15 years, even though the global population rose by two billion over the same period. Unfortunately, this positive trend then stalled, and the number of people suffering from malnutrition and undernourishment has been increasing again worldwide for a number of years.

Number of undernourished people worldwide between 1990 and 2018 Source: Statista

* Estimate

THE FOOD REVOLUTION



TEXT INGA OLFEN

Nearly ten billion people will be living on the planet in 2050—but what will all these people eat? Far-reaching changes will have to be made—and quickly—if a sufficient amount of healthy food is to be made available to the world’s population without putting excessive strain on the Earth’s natural resources

The old tradition of the “Sunday roast” may hold the key to ensuring that enough food can be provided to everyone in 30 years. This will be a major challenge, given the continued growth of the global population and the increasing intensification of climate change. “We need to go back to the principle of the ‘Sunday roast,’” says biologist Alexander Popp. What he means is that we need to be more aware of how much meat we eat in all of its forms—more particularly, we need to consume meat less frequently. Popp works at the Potsdam Institute for Climate Impact Research and is one of the more than 100 authors of a special report recently published by the Intergovernmental Panel on Climate Change (IPCC). Among other things, this report points out that global per capita meat consumption has more than doubled since the 1960s.

Most scientists agree that food will be a key issue of the 21st century, and meat is only one aspect of it. The way we feed ourselves and the sources of the food we eat will decide how we live in the future. The Earth’s population is currently around 7.7 billion. Despite the extensive progress made over the last few decades, the Welthungerhilfe aid agency reports that two billion people still suffer from malnutrition, and this figure also includes people in the industrialized nations. Of these two billion people, more than 820 million suffer from hunger.

GREATER PROSPERITY LEADS TO HIGHER CONSUMPTION

A look into the future makes the challenge we face very clear: The Earth’s population could rise to as many as ten billion people by 2050, which would correspond to a one-third increase. All these people will likely consume around 50 percent more food than →

A shining example?
Vegetables are grown under LED spotlights in a hall in New Jersey in the USA



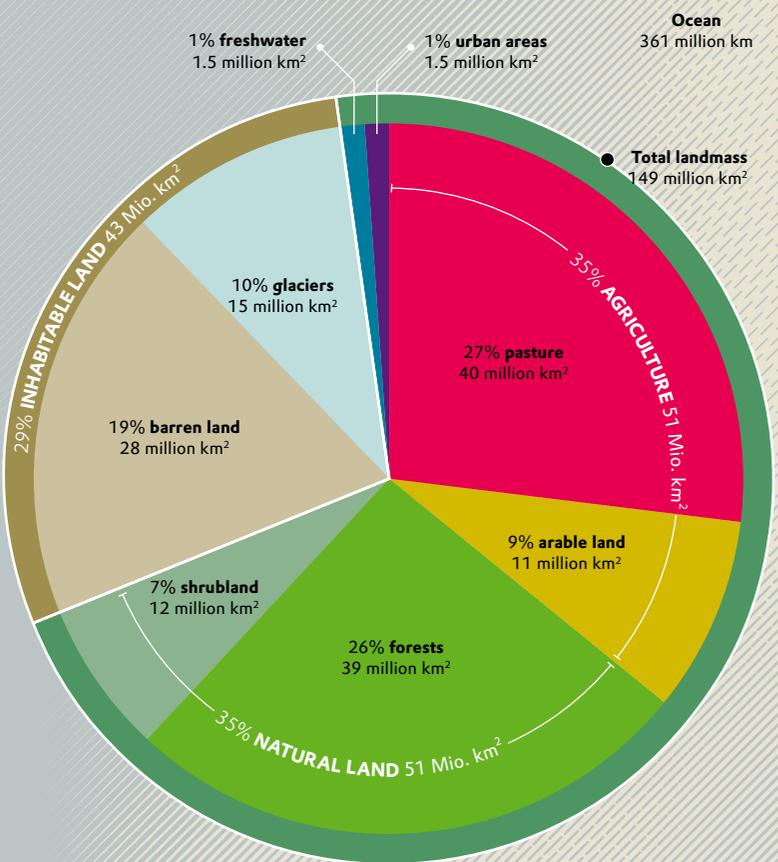
FROM FARM TO FORK

We wouldn't have any food without agriculture. But how many resources do crops and animal farming consume? And what happens to the food products? An overview of the key facts

Sources: National Geographic, OECD, FAO, AT Kearney, University of Twente, WWF

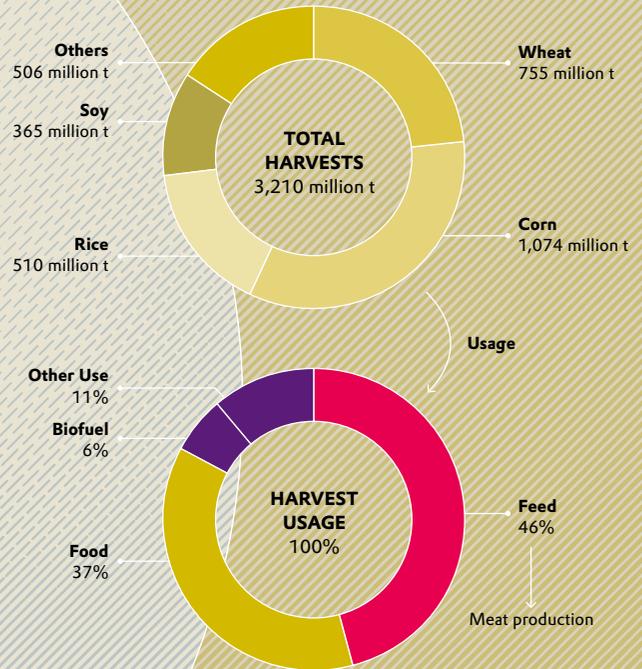
How land is used worldwide (in km²)

About half of the habitable part of the Earth's surface (approximately 51 million square kilometers) is used for agricultural purposes. Over the past 200 years, people have cleared forested areas the size of South America in order to grow crops and raise livestock. This has had a big impact on the amount of CO₂ in the atmosphere.



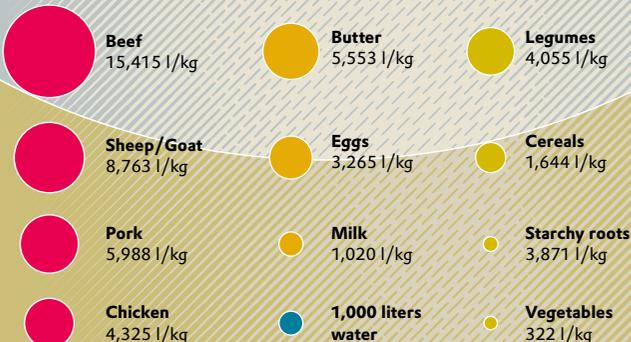
How the world's harvests are used, in millions of tons (t)

More than 3.2 billion tons of crops were harvested in 2018. Most of it was corn. However, only slightly more than one third of the harvests are directly used for food. Almost half is turned into animal feed. This is especially the case with soybeans, which are grown on a particularly large scale in the USA, Brazil, and Argentina.



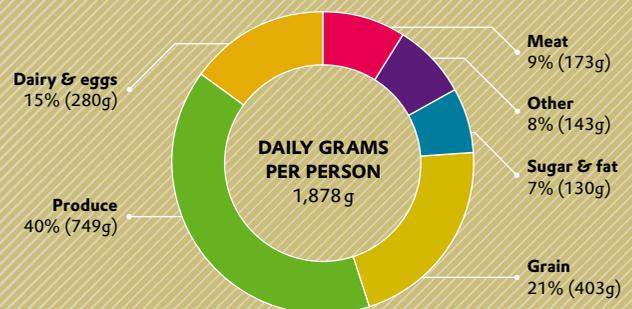
Water use for food production, in liters per kilogram of end product

Widely different amounts of water are needed for the production of the various types of food. While two bathtubs full of water are needed on average to grow a kilogram of vegetables, almost 100 bathtubs full are required for one kilogram of beef.



What people eat worldwide (global averages)

People's diets consist primarily of fruits and vegetables, followed by grain, dairy products, and eggs. However, the size and composition of meals varies greatly, depending on the region and the individual person.





Small farms, such as this one in Ghana, dominate the agricultural sector in Africa

today's global population. That's because incomes are on the rise in developing countries and emerging markets—and when prosperity increases, per capita food consumption increases along with it.

The question is: Can the planet accommodate this increase? Experts say it can. A report on future global food supplies that was published at the beginning of this year by the EAT Lancet Commission states that providing ten billion people with a healthy diet is both necessary and possible, although being able to do so will require a radical transformation. The members of the EAT Lancet Commission, which was established on the initiative of the renowned British medical journal *The Lancet*, believe that our eating habits around the globe need to change fundamentally. More specifically, people need to eat twice as much plant-based food (fruits, vegetables, legumes, nuts) as they do today and reduce their consumption of meat (including eggs) and sugar by at least 50 percent.

In order to understand why our diets are believed to have such a major influence here, one needs to understand that food production already accounts for 70 percent of total drinking water consumption, as well as 20 to 30 percent of greenhouse gas emissions.

MORE EFFICIENT PRODUCTION

Only a little more than half of all plant-based calories produced worldwide today are consumed directly by human beings. More than one third of all crops are used to feed animals (see the chart on the opposite page). Of every 100 calories from the plants used to feed livestock, 40 make their way into the milk we drink, while 22 calories are left in eggs, and only three calories in beef. Food is the most effective means of optimizing human health and environmental sustainability around the globe, according to a report pub-



Free-range animals: These Iberian pigs eat acorns

lished by the Food and Agriculture Organization of the United Nations (FAO) in 2016.

A similar view is taken by the World Resources Institute (WRI), which in its latest report, "Creating a Sustainable Food Future" (2019), calls for a dramatic increase in the efficiency of natural resource utilization. Ultimately, compatibility between environmental protection objectives and food availability can only be achieved through an increase in productivity. More specifically, this means that we need to increase the crop yields and milk and meat production achieved with each animal and acre of land used, and with each kilogram of fertilizer applied to the soil. "If today's levels of production efficiency were to remain constant through 2050, then feeding the planet would entail clearing most of the world's remaining forests," states the report.

Innovative technologies and more extensive global cooperation are needed in order to increase productivity while still conserving resources. In its report, the WRI lays out the most important challenges we face. It states that significant improvements in feed →

quality and grazing management are needed in order to prevent even more surface area from being converted into farmland.

New approaches for livestock breeding are designed to improve what is known as the feed conversion rate: When livestock process their food more effectively, fewer crops have to be planted to feed them (see article on page 16). With regard to aquacultures, alternatives to fish meal are increasingly being used, as production of the latter uses up a large amount of natural fish resources (see article on page 32). If fish production were made more sustainable, fish yields could be increased significantly, according to the WRI report. This, in turn, would make it possible to provide more people with the important proteins they need.

The fishing grounds off the coast of Senegal are a popular destination for international fishing fleets



Another effective approach, according to the WRI, would be to reduce the amount of food that is wasted and thrown away. Indeed, nowhere near all of the food that is produced today is actually used for its intended purpose, which is to feed people. According to the EAT Lancet Commission, as much as 30 percent of the food produced around the world ends up in the garbage. Sometimes this is due to the fact that it spoils during transport, while in other cases food is stored incorrectly. Then there's the food that's thrown away before it reaches the supermarket because of its flawed appearance. In addition, many consumers buy too much food and then don't use or store it properly (see article on page 56).

Many people in rich countries can afford this kind of behavior, since there's plenty more food to be had. Whereas nearly one third of the population of East Africa doesn't have enough to eat, people in the industrialized countries are getting fatter and fatter on average. A grown man in Afghanistan consumes 2,100 kilocalories on

“Providing ten billion people with a healthy diet is both necessary and possible”

EAT LANCET COMMISSION



India is the world's leading exporter of beef, ahead of Brazil and Australia



Lettuce harvest on an organic farm in California: The USA is one of the biggest producers of organic foods

average every day; the figures for Germany and the USA are 3,500 and more than 3,600, respectively. The German Nutrition Society (DGE) recommends a diet of 2,500–2,800 kilocalories per day for a middle-aged man who is moderately physically active.

Around 1.9 billion people around the world are overweight, and more than 600 million of these people are obese. That figure corresponds to one out of every eight adults. The impact this has on health is considerable: In an international study with just under four million participants, researchers under the direction of epidemiologist Emanuele Di Angelantonio from the University of Cambridge were able to establish a direct correlation between excess weight and lower life expectancy.

THE BEST ASPECTS OF TWO APPROACHES

There is a dispute among scientists regarding the best approach to take in order to produce food in a more productive and sustainable manner. In conventional agriculture, crop yields can be raised through more extensive mechanization and the use of modern irrigation methods, artificial fertilizer, and genetic engineering. Digitalization can also play a role here: Drones are already providing real-time images of livestock and fields, thereby making it possible

to direct water, nutrients, and pesticides to where they're needed. Sensors are also used to collect data on weather, plant growth, soil quality, and livestock health. These sensors are designed to ensure maximum crop yields and minimal crop damage.

On the other hand, those who favor local agricultural organizations and organic farming believe that the huge numbers of small farmers around the globe could increase their crop yields simply by improving soil fertility through the use of compost or by combining different types of plants in an effective way. These people also believe that advances in agricultural engineering could be applied here as well (see interview on page 24). “Both approaches offer solutions,” says Dr. Jonathan Foley, a world-renowned environmental scientist. “Each one by itself cannot get us where we need to go. The best thing to do would be to combine the best aspects of both approaches.”

Such combined expertise is also favored by Rajiv Shah, President of the Rockefeller Foundation and a member of the World Economic Forum. He states that a new food revolution has the potential to sustain our families and our planet. However, in order to solve the world's biggest problems, mankind needs to expand all of the capacities available to it. —



A CLOSE LOOK

TEXT TOM RADEMACHER



Evonik's precision livestock farming is bringing big data and biotech to poultry farming. The aim is ambitious: To produce meat from fewer resources while also improving animal welfare



“We can spot the outbreak of a disease five days in advance, without having to slaughter a single bird”

DR. EMEKA IGWE, BIOTECHNOLOGIST

Gerd Aepker knows whether his chickens are doing well. “You see it in the way they move,” says the 70-year-old farmer. Nearly 20 years ago, he converted his small family farm into a large-scale intensive farming facility. Gerd's son André now runs the farm. It consists of two grow out houses, each of which is over 80 meters long. They are located in the midst of wheat fields in a rural area between Bielefeld and Bremen. Some 74,000 chicks of the Ross 308 breed scurry around inside the buildings. The fuzzy chicks are three days old and about the size of tennis balls. On this morning, men and women wearing overalls and rubber boots collect chicken dung in bags as they carefully walk through the throngs of chicks. They are conducting this unsavory task for the sake of science and the animals' welfare—as well as for the future of agriculture.

DATA HEIGHTENS PRECISION

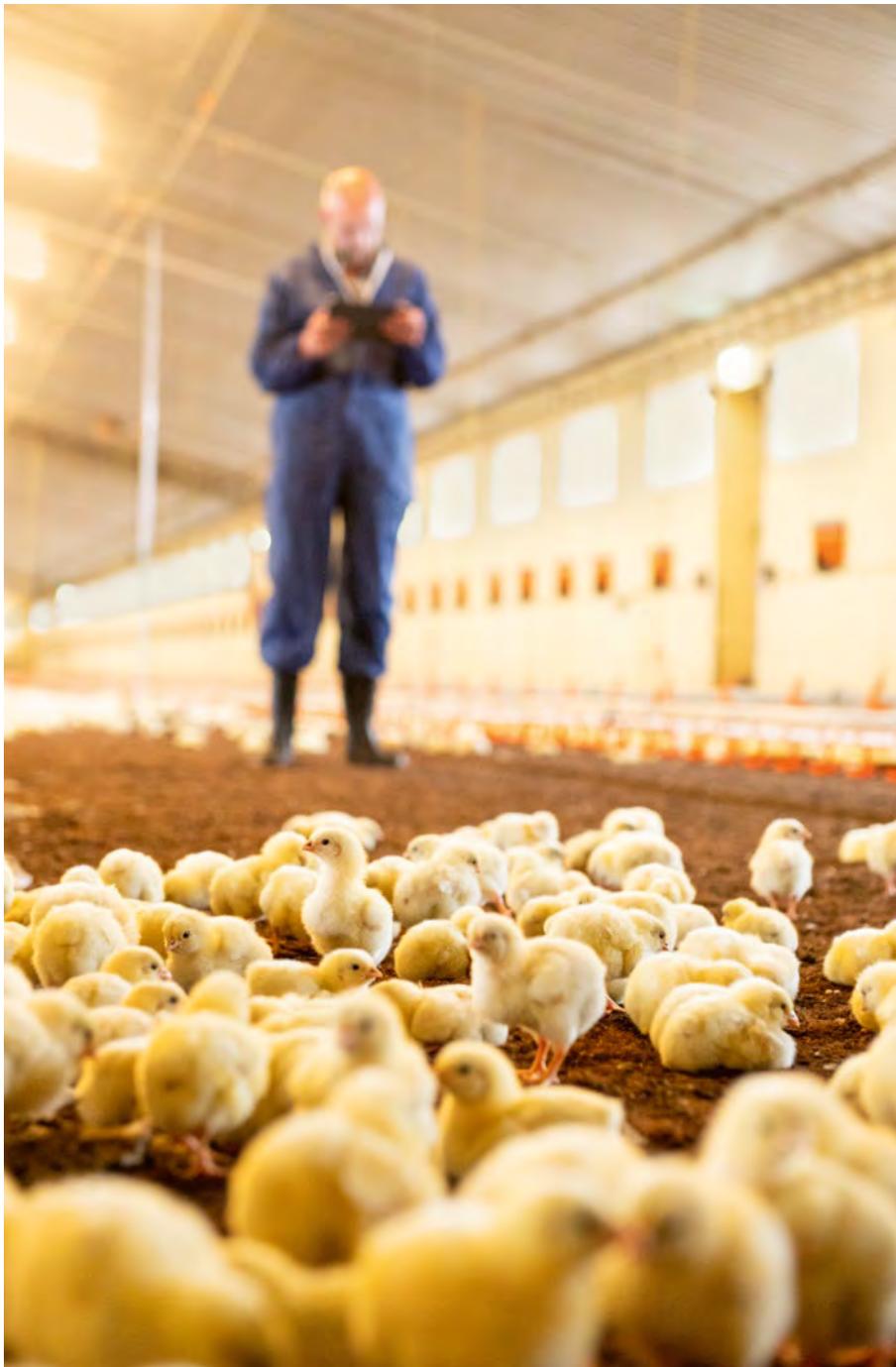
The people collecting dung in Aepker's chicken coop are biotechnologists from Evonik. For many years now, the Essen-based company has been supplying feed manufacturers with additives that enable animals to process the feed more effectively. As a result, Evonik has laid the groundstone for making meat production more efficient and sustainable. On this basis, the company is now developing solutions for improving productivity, quality, and the animals' welfare in the grow out houses.

Meat production has a huge impact on the environment and the climate. Animal husbandry generates large nitrogen inputs that contaminate the soil, air, and

groundwater. A large part of agricultural land is used to grow animal feed. Moreover, natural ecosystems are being replaced by fields and pastures, a development that reduces biodiversity. Areas that once were covered by rainforests are now used to grow soybeans, which are an important raw material for animal feed. All of these effects combined contribute to meat production's environmental footprint.

Radical change is needed if the demand for meat by the world's burgeoning population is to be met without putting too great a strain on the Earth's resources. The objective must be to produce meat with fewer resources while not losing sight of the animals' needs. One of the solutions to these urgent food issues is precision livestock farming, or PLF for short. It's a mix between big data, new networked technologies, and a holistic understanding of ways to keep animals healthy.

Less than an hour's drive to the south of Aepker's farm is an Evonik lab, where Dr. Emeka Igwe bends over his laptop. Here in Halle-Künsebeck, Igwe performs a feat that astounds even experienced farmers: →



At the Aepker farm in eastern Westphalia, 74,000 chicks are constantly monitored over the 40 days they take to reach slaughter weight

soon as it accounts for a certain proportion of the intestinal flora.” This illness costs the world’s chicken farmers billions of euros every year. The disease perforates the chickens’ gut, causing the birds to suffer and grow poorly. Once the disease has broken out, only antibiotics will help.

To determine if the illness had taken hold, a random sampling of animals used to have to be killed and their intestines examined. Without slaughtering a single chicken, Igwe and his team can now detect an outbreak five days before it occurs. More than 90 percent of these forecasts are accurate. This warning time enables farmers to take gentle countermeasures such as the addition of butyrate (the salt of an organic acid) to the birds’ drinking water. This acid is also produced by the microbial inhabitants of the chickens’ guts. The butyrate causes the pathogens to die off by changing the intestinal pH value.

Evonik has developed such tests for four of the most common problematic microbes in chicken farming. Igwe is currently busy demonstrating these tests all over the world. Most recently, he did it at an American company that operates around 350 feedlots permanently holding a population of 56 million animals. “Although such conglomerates have their own labs and veterinarians, they still can’t do what we can,” says Igwe. A chicken feedlot in China recently needed Igwe’s help to track down a contaminated source of drinking water.

Aepker’s farm isn’t really typical of what Evonik generally deals with. The farm is much too small. However, Benjamin, the older of the two Aepker brothers, works for Evonik in Halle-Künsebeck. As a result, some new developments from Evonik are first tested in Aepker’s grow out houses. “This is where we find out what the farmers’ concerns are,” says Igwe.

LOTS OF FEED, LITTLE DUNG

Time doesn’t stand still in Aepker’s farm either. When André took over his father’s farm, he doubled the size of the grow out houses while at the same time reducing the relative number of animals. “This change was made to fulfill the criteria of the German government’s animal welfare label,” explains Aepker. The number of an-

The graphs on Igwe’s laptop tell biotechnologists not only how well Aepker’s chickens are currently doing but also how healthy they’ll be next week. This feat is made possible by a new testing method called ScreenFloX®. This technique analyzes telltale genetic fingerprints to identify pathogens in chicken dung. The process is similar to the way forensic experts detect traces of DNA at crime scenes. But Igwe knows not only whether pathogens are in the dung also but how many of them there are. That’s the crucial point.

GENTLE METHODS

“The bacterium *Clostridium perfringens*, for example, can be found almost everywhere,” explains Igwe. “However, it can trigger subclinical necrotic enteritis as

imals is reduced further before they reach the target slaughter weight. Smaller chickens are sold as broilers. This gives the other birds more room until they reach their target slaughter weight of 2.7 kilograms. Pecking stones reduce the chickens' stress levels and help their digestion. Because chickens don't have teeth, they swallow stones that grind the food in their gizzards.

The efficient processing of feed is absolutely essential in animal husbandry, because feeding the livestock accounts for around one third of the total costs. Shortly before Aepker's chickens are slaughtered, they consume eleven tons of feed—per day. A chicken needs to consume about 1.7 kilograms of feed in order to gain one kilogram of weight. Only 1.5 kilograms is needed if the feed is optimized. By contrast, pigs need to consume almost three kilograms of feed to gain one kilogram of weight, while cattle generally have to eat more

than six kilograms. Aepker also has to pay for the disposal of the dung. As a result, as little of the feed as possible should be turned into dung.

The chicks at Aepker's farm reach their target weight in 40 days. The feed mixture is adapted to the animals' needs as they go through five growth stages. A large proportion of the feed consumed at Aepker's farm consists of locally grown wheat. The grain is ground so that the chickens can digest it better. A mixture of protein, vitamins, minerals, and essential amino acids (including methionine) is added to the feed. This admixture is necessary because sources of vegetable protein generally contain relatively little methionine. Without this amino acid, chickens are unable to efficiently process the other ingredients (see box on page 21).

Evonik is one of the leading manufacturers of methionine, which it produces in Germany, Belgium, the USA, and Singapore. Moreover the company offers additional amino acid products to offset deficits in the feed. Special variants of methionine have been tailored for dairy cows, fish, and shrimps.

ENVIRONMENTAL BENEFITS IN FIGURES

Amino acids offer measurable benefits, particularly for the intensive farming of chickens and pigs. Farms that use Evonik's feed additives and feeding concepts significantly reduce the strain on the environment. "If the entire sector operated in this way, it would be possible to cut greenhouse gas emissions by around 60 million tons in 2030, while the amount of farmland could be reduced by 17 million hectares and nitrogen emissions by six million tons," says Dr. Ralf Kelle, who is responsible for sustainability at Evonik's Nutrition & Care Segment.

The composition of a feed mixture's raw materials has to be known so that it can be determined how much of an amino acid has to be added. Since 1997, Evonik has maintained what is now the biggest database of the amino acid content of fodder crops worldwide. Customers can now benefit from this knowledge, thanks to a smartphone app. Feed manufacturers can even have Evonik analyze their raw materials within minutes by means of near infrared (NIR) spectroscopy. →

Farmer André Aepker hears the results of the analysis of the samples taken in the grow out house from Evonik employee Dr. Frank Thiemann (left)





In order to obtain viable results, a specific method is used to collect the dung samples everywhere in the chicken coop

Precision livestock farming will now provide deeper insights into animals and the conditions under which they are kept. In 2018 alone, Evonik invested in three startups that are pointing the way. The Dutch startup InOvo has developed a technology that can identify the gender of chicks before they hatch. As a result, male chicks may no longer get shredded. Optifarm, a startup from England, uses sensors and cameras to monitor chicken coops worldwide. Evonik has completely acquired another startup, Porphyrio, which was spun off by KU Leuven, a Belgian university. This startup develops big data systems and adaptive algorithms for making forecasts in all areas of poultry farming.

GOOD GERMS INSTEAD OF ANTIBIOTICS

“Precision livestock farming aims to achieve a holistic understanding of animal welfare and to make forecasts that are as precise as possible,” says Professor Stefan Pelzer, Head of Research for Gut Health Solutions at Animal Nutrition. Pelzer and the Belgian company ProDigest have developed an important tool for this purpose: the Dynamic Avian Intestine In-vitro System (DAISY). This system is the result of a publicly funded research project and consists of a laboratory model of the chicken intestine. DAISY uses a cascade of glass containers to precisely simulate microbiological processes in chicken guts. “Medicine has recently learned a lot about how the intestine and its microbi-



Evonik employee Michelle Dargatz prepares a sample in a multistage process in Halle-Künsebeck

ome influence human health,” says Pelzer. DAISY is helping Pelzer and his team in Halle-Künsebeck to gather data and findings that will enable them to reduce the use of antibiotics in animal husbandry to a therapeutically necessary level.

Antibiotics have been used as growth promoters in animal husbandry since the 1950s. Although this practice was banned in the European Union in 2006, it is still common in other parts of the world. Experts fear that this practice breeds pathogens that are resistant to ever more antibiotics and thus endanger human beings.

“Our aim is to gain a holistic understanding of animal welfare”

PROF. STEFAN PELZER, HEAD OF RESEARCH FOR GUT HEALTH SOLUTIONS AT ANIMAL NUTRITION



However, another problem arises if antibiotics aren't used: Chicks have a weak intestinal flora if they don't have any contact with their mothers after they hatch and are thus unable to acquire any good bacteria from them. Such chicks are less robust and more likely to be affected by harmful germs.

To solve this problem, Evonik is using probiotics. In 2016 the Group acquired the probiotics business of the Spanish company NOREL. One year later, Evonik launched its first probiotics product to be developed in-house. It contains a strain of *Bacillus subtilis* that outperformed more than 500 other strains of bacteria in tests. The product counteracts the conditions that foster necrotic enteritis. In addition, it can withstand high temperatures during processing in the feed mill.

Farmers rely on their experience. “When the ground in the chicken coop gets moist, it means that something is wrong with the birds' digestion,” says André Aepker. “When that happens, the first thing we do is to put more wheat into the feed. In most cases, that puts their intestines right again.” However, many farmers are also willing to try out new methods. Aepker Sr., for example, experimented with probiotics several years ago. He says this was very tiresome, “because I had to stir them myself and then let them ferment.” Moreover, they didn't do a whole lot of good. But Aepker would try probiotics if they were already mixed in with the feed and were proven to be effective.

Probiotics are only one of the many different elements of precision livestock farming. “Advanced feeding concepts, the targeted inclusion of nutritional and functional feed additives, the strengthening of the animal's intestinal systems, and the optimization of farming conditions—all of this helps to make animal husbandry fit for the future,” says Pelzer. He hopes that this holistic approach will make it possible to produce meat more sustainably in the future and with less of an environmental impact. Everyone will benefit from this in the end.

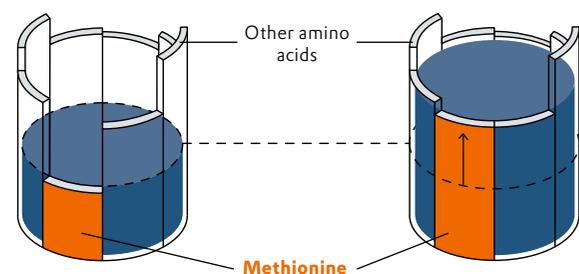
“I like chickens,” says André Aepker as we depart. He couldn't do the job otherwise. “Mentally, you're always with the animals,” he says. The chickens' welfare is of existential importance for Aepker. When he closes the door to the chicken coop, we see a yellowed sticker that says: “Niemand soll es je vergessen, Bauern sorgen für das Essen” (Nobody should ever forget that farmers provide their food). —

A barrel full of amino acids

Amino acids are often called the “building blocks of life.” This should be understood literally. Every living organism on Earth connects amino acids into long chains of proteins that serve as the elements of everything from the DNA of the bark beetle to the cartilage in a knee joint. In order to produce certain proteins, humans and animals have to obtain essential amino acids through their food intake. The problem is that if even a single building block is missing, the others will be excreted without being used. In the 19th century, the German chemist Justus Liebig compared this law of the minimum to a barrel in which each stave represents a different building block. In this image, the shortest stave is the “first limiting” amino acid. In the case of chickens, this is methionine. If you specifically increase the amount of methionine in feed, the other nutrients will also become more usable.

Animal feed based on vegetable proteins:

Admixture of DL-methionine



Where's the Beef?

Traditional hamburger patties are facing competition from alternatives made of plant-based raw materials or cultivated animal stem cells. This is how they are produced:

PLANT-BASED MEAT

Companies such as Impossible Foods and Beyond Meat are booming. That's because it's nearly impossible to tell the difference between their plant-based meat substitutes and real meat. The recipes are varied and generally secret. However, we do know a few facts about them.

The basic elements are **plant proteins**, for example legumes such as **soybeans** and **peas**. The addition of **potatoes** or **rice** adds crispness and roast aromas when the patties are fried.

Modern processing technology gives the protein a **meaty structure**. For example, in the wet extrusion process, the raw mass is pressed through a **nozzle** and simultaneously cooked.

The iron compound called heme is an important component of the blood of all vertebrates. Soybean plants produce small amounts of it in their **roots**. If the corresponding **DNA** is implanted in **yeast cells**, heme can be produced in a bioreactor.

Heme gives the protein mass its red color and meaty taste. Other ingredients include **spices, flavorings, vitamins, and minerals**.

Plant-based oil makes the burgers juicy. **Coconut oil** has the advantage of remaining solid until it is **heated**. It only melts in the pan—just like animal fats.

To make the mass cohere, **methylcellulose** is added. It's the main component of wallpaper paste—but in the form of E 461 it also thickens many foods, ranging from ice cream to mayonnaise.



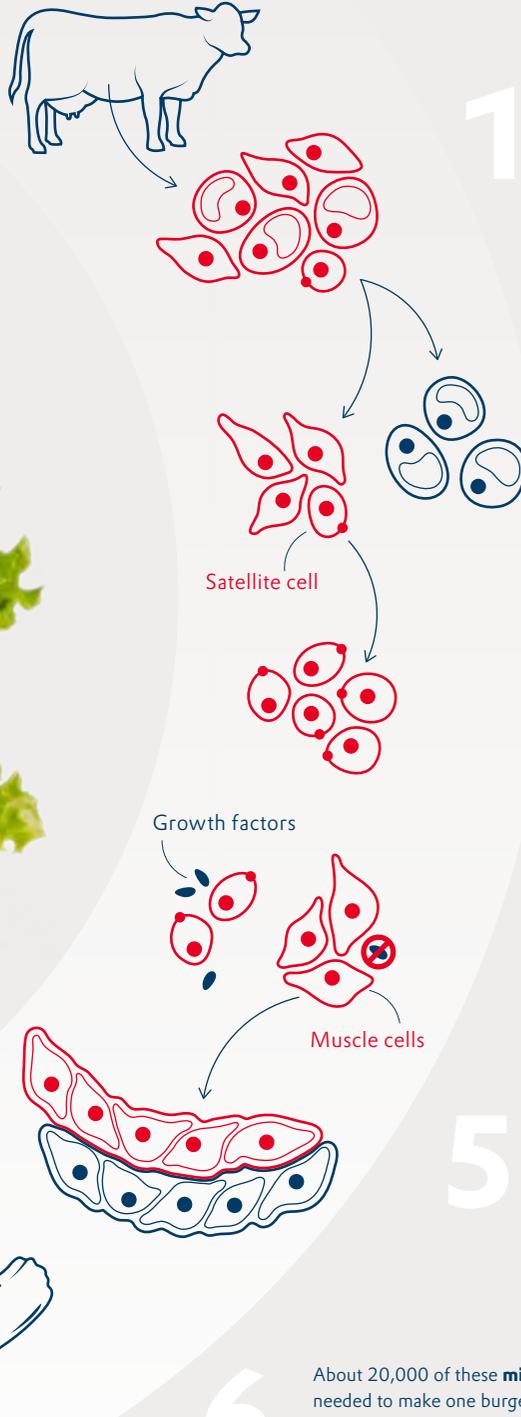
MEAT FROM THE LAB

Producing meat without slaughtering animals—that’s the promise of the scientists developing in vitro meat. A number of companies are trying to grow real meat based on cell samples taken from animals, mainly chickens, pigs, cows, and fish.



€250,000

That’s the approximate cost of the first hamburger cultivated in a laboratory. A University of Maastricht research team headed by Mark Post sampled this delicacy in front of TV cameras in 2013. According to Post, burger patties like this one can soon be produced at a cost of about €10.



1

After administering local anesthesia, a small sample of muscle tissue is removed from a healthy animal. A few hundred **cells** are enough.

2

The **muscle cells** are separated from the **fat cells**. The **satellite cells** are isolated from the muscle cells. These are special stem cells that repair damaged muscle.

3

When placed in the right nutrient solution, **satellite cells** multiply almost endlessly. Theoretically, ten tons of tissue could be cultivated from a single cell. The nutrient solution required for this is often still based on calf serum. Companies are looking for plant-based alternatives.

4

If the amount of certain proteins known as **growth factors** in the nutrient solution is reduced, the satellite cells react by forming **muscle cells (myoblasts)**.

5

Myoblasts autonomously organize themselves into fibers called **myotubes**, which are only up to a third of a millimeter long. When they are correctly organized on a flexible carrier, they form tiny muscle fibers and begin to contract. The muscle “trains” itself and increases in mass.

6

About 20,000 of these **mini-muscles** are needed to make one burger patty. They can be processed in the same way as ground beef. The only thing now missing is **fat**—either plant-based or cultivated fat.



Felix Prinz zu Löwenstein (63) is the Chairman of the Federation of the Organic Food Industry (BÖLW), the umbrella association of producers, processors, and traders of organic food in Germany. After receiving a doctorate in agricultural science, Löwenstein initially worked in the area of development assistance. He subsequently took ownership of his family estate in Otzberg-Habitzheim and converted it into an organic farm. He has published two books, *Food Crash* (2011) and *Es ist genug für alle da* (There's Enough for Everyone) (2015), in which he criticizes industrial agriculture. The photographs were made in the greenhouses of the cooperative, which was founded in 2018 to produce organic food in Frankfurt-Oberrad

"The Prices Lie"

Which type of agriculture—organic or conventional—provides better responses to the demands of global nutrition? Dr. Felix Prinz zu Löwenstein, an advocate of organic farming, talks about technological progress in agriculture, sustainable agricultural policy, and the true cost of a roast chicken

INTERVIEW **CHRISTIAN BAULIG AND JÖRG WAGNER**
PHOTOGRAPHY **ROBERT EICKELPOTH**

The glass towers of the major banks in Frankfurt can be seen on the other side of the Main River. In the glass greenhouses of the cooperative on the river's southern bank, the aim is the same: growth. But here it's not about assets—it's all about tomatoes and Swiss chard. On five hectares, the cooperative produces vegetables for its members, in line with the standards of the organic agriculture association Naturland. Almost 500 people from the region are members; some of them lend a hand here as well. This is where we meet Felix Prinz zu Löwenstein, who has an organic farm of his own in southern Hesse, for a talk.

In the Fridays for Future demos, hundreds of thousands of people are taking to the streets to demand protection for the climate—and a more sustainable approach to nutrition. Are you gratified by this development?

Agriculture too must help to achieve the climate goals. We knew that even before the demos. In Germany

alone, we need to reduce our carbon dioxide emissions by 13 million tons per year. Unfortunately, our politicians lack the courage to make a real change. Above all, we need to reduce the input of nitrogen and nitrates into our ecosystems, for example by significantly reducing livestock density—but people don't dare to do that.

What needs to happen in order to change producers' and consumers' behavior?

The policymakers must create a framework in which the prices of different foods reflect the true costs of their production. For example, the horn shavings that we use as a natural fertilizer in organic agriculture cost between three and four euros per kilogram of nitrogen. Conventional nitrogen fertilizer can be bought for as little as one euro per kilo. However, its true costs, which include the costs resulting from the pollution of groundwater and the atmosphere, are considerably higher. The same principle applies to chemically synthesized pesticides. However, it would be naïve to expect broad segments of the population to go to the trouble of analyzing these external costs. This is where policymakers need to act.

The German government has declared that in the future a price will be put on greenhouse gas emissions in agriculture...

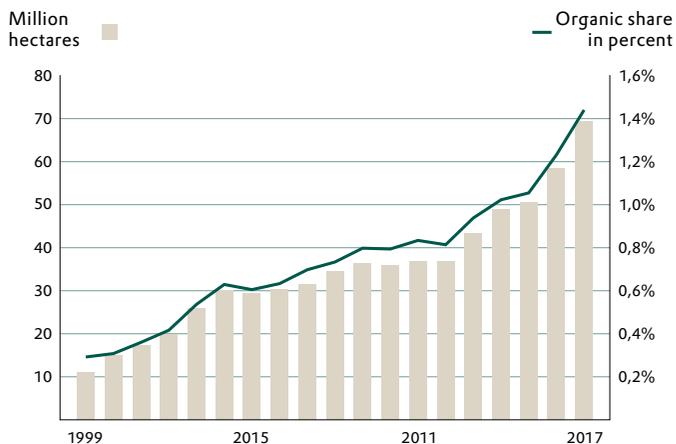
Yes, ten euros per ton. That's a joke.

In your opinion, what are the most effective measures that must be implemented today?

In Europe the EU's Common Agricultural Policy must be restructured. Every year, the EU distributes €55 billion to agricultural enterprises—that's 16 percent of their gross value added. At Evonik, a financial backer as important as this would be influencing corporate policy. But in the field of agriculture, the European →

A boom in the niche

Source: FiBL-IFOAM-SOEL-Surveys 1999–2019



At the end of 2017, almost 70 million hectares of land worldwide were devoted to organic farming. According to the Research Institute of Organic Agriculture (FiBL) and IFOAM—Organics International, that amounts to about 1.4 percent of all agricultural land. This percentage has recently been growing by 20 percent annually. The largest areas of organic farmland are in Australia (35.6 million hectares), Argentina (3.4 million hectares), and China (3 million hectares). Organic farming operations commit themselves to basically avoiding the use of synthetic pesticides and herbicides, mineral fertilizer, and green genetic engineering. In animal husbandry, some types of feed are prohibited, and the required minimal amount of space per animal is defined more generously. Before an operation can market its products as “organic,” it must go through a transitional phase lasting several years, as a rule. In the European Union, the concept of “organic” is protected by the EC Organic Regulation. Since 2010, products raised in accordance with this regulation can be labeled with the EU organic logo. In the USA, products must be certified by the Department of Agriculture before they can be labeled “organic.”

Union is not exerting any influence on corporate policy. Instead, 80 percent of the funds are distributed in line with the “watering can” principle, according to how many hectares of land are under cultivation. The funds should be used to pay farmers for the work they do that is needed by society, but that the market does not pay them for.

For the conservation of fruitful soil, for example?

Exactly. The second measure is a change in the EU’s trade policy. The new President of the European Commission, Ursula von der Leyen, recently said she could imagine charging import duties at the EU’s external borders in order to balance out the differences between the environmental effects of various products.



Prinz zu Löwenstein talks to the *Elements* reporters Christian Baulig (left) and Jörg Wagner

That was a good proposal, and it also conforms to the rules of the World Trade Organization, the WTO. Among other things, that would raise the price of soybeans, through which we’re importing lots of nitrogen emissions from overseas. The third measure is the further development of organic farming. We must do more research in this area so that it can become the right path for everyone.

By 2050, it’s likely that agriculture will have to feed more than nine billion people on earth. In the face of this challenge, shouldn’t we be focusing more strongly on highly efficient mass production?

Of course we should produce as much food as possible—but not in ways that destroy the foundations of food production. Biodiversity is the foundation of plant production. If we destroy it, the fact that we used to have high yields won’t do us any good. The same thing applies to soil fertility and climate stability. If I burn a pile of straw, I’ll be nice and warm for a while, but after the straw has been burned up, I’ll feel cold pretty soon.



During the summer months, the cooperative produces huge amounts of tomatoes and other produce. Some members help with the harvesting



Prinz zu Löwenstein demands that farmers be more effectively rewarded for practicing sustainable agriculture

Organic farming offers good solutions, but it requires a lot of space. If we wanted to raise all the broiler chickens in Germany according to the rules of organic farming, half of the state of Hesse would have to be turned into open-air chicken coops. Is that what you want?

People often make the following simplistic argument: “If we were to do organic farming everywhere, we would produce less food. That’s why we need more space, so we’ll have to turn even the last nature reserve into farmland.” I hear this from people who haven’t paid any attention to market theory and who don’t know that altered prices change people’s consumption patterns. That applies especially to meat, whose production requires the largest proportion of land. The claim that “economies of scale” make it possible to produce more on large farms than on small ones is simply false. Today you can work more productively in smart small-scale farming than in a large agricultural enterprise. Between 50 and 70 percent of the world’s agricultural products are raised on farms that are smaller than two hectares. Especially in developing

countries, farmers can cultivate small areas much more intensely than large-scale growers can. Industrial growers often force small farmers out of business and then use the land to raise fodder crops instead of food.

Many people reach for conventionally produced items on supermarket shelves because they are usually cheaper than the organically produced alternatives...

Yes, because the prices lie, and most of the real costs are being passed along to the general public or future generations. But we can’t afford to pursue social policies at the environment’s expense. It would be shortsighted to continue practicing agriculture the way we have done so far just to enable poor people to eat more meat. We would help poor people more if we stopped wasting 20 percent of our food on the way →



Prinz zu Löwenstein is skeptical about in vitro meat production



More vegetables, less meat—many organic farming operations are calling for new approaches to nutrition

to the store and 30 percent more on the way to the consumer. Poor people are already suffering more than rich ones from the consequences of environmental damage.

Nonetheless, some people feel that urging people to buy more organic food is elitist. An organically raised chicken is delicious, but it costs €20.

If we start from the realization that our food budget is limited, we simply have to significantly reduce our meat consumption. A project in Denmark is demonstrating that this transition within a fixed cost framework actually works. The city of Copenhagen has ordered that 90 percent of the food served in all of its public canteens must be organic—and it has reached this target. The guests are well-fed, but less meat is being served and less food is being thrown away. As you can see, this discussion is not only about productivity.

Several startups have started to grow meat from the cells of chickens, cattle or pigs. Can this technology help to solve the problems connected with meat consumption?

We'd have to find out where the nutrient solution came from and how much energy was needed. This method might turn out to be more efficient than chicken breeding, and a chicken nugget might someday no longer cost €8,000.

It already costs less than \$100 today.

All the same, I'm still skeptical—and I'm also skeptical about indoor production facilities where vegetables grow aseptically under artificial light. There's a connection between the soil and the quality of the products that are grown in it. Winegrowers call it terroir. Human beings started to grow crops and breed animals 10,000 years ago, and since then we have continued to develop, together with our foods. Never before has our diet changed as much as it has in the last five decades. Many problems in our man-made environment have arisen because we have moved as far as we possibly could from natural relationships. So it might be wise to realign ourselves with natural systems and the ways they function.

Even if we want to have entirely organic nutrition, it would take many years to reorganize agriculture.



The first tomato plants have already been dug up in the early fall. Growing in the background are winter vegetables such as Swiss chard

“In 15 years we will no longer need any chemicals for removing weeds from our fields”

Shouldn't we direct all our efforts at making conventional food production as sustainable as possible?

Of course we have to reorganize agriculture in ways that enable it to cause less damage than it does today. For example, we shouldn't accept the fact that today every pig is given antibiotics at least once in its life. We have to make sure that a chicken is once again treated like a chicken rather than a factory product. We need stable systems that do not constantly depend on external interventions. A small farmer in the Philippines who raises 90 different kinds of plants on one hectare has a completely stable system. We can learn a great deal from that.

Technologies such as precision farming that are being promoted by industry are benefiting organic farming as well as conventional agriculture.

That's partly true. Agricultural engineering is in fact developing at a rapid pace, thanks to digitalization. I would wager that in 15 years we will no longer need any chemicals for removing weeds from our fields, thanks to improved mechanical methods. I'm personally very interested in this topic because of our cultivation of herbs and medicinal plants—they need to be raised in a completely weed-free environment. If you want to raise marigolds for skin care products, you don't want to have poppies growing among them.

When it comes to protecting the environment, the human race is turning out to be capable of learning. For example, the hole in the ozone layer has shrunk because of the ban on CFC emissions. Are you hopeful that we can also get things moving in the area of nutrition?

We must create underlying conditions that prohibit people from producing cheap products at the cost of the general welfare. Things are already moving in this direction: Sales of organically produced food are already growing year on year by as much as ten percent. And ten years ago you would probably not have been able to find enough families in Frankfurt to set up a vegetable-growing cooperative. —



Johann-Caspar Gammelin is the Chairman of the Management Board at Evonik Nutrition & Care

Healthy Animals, Healthy People, Healthy Planet

by Johann-Caspar Gammelin

Nutrition is one of the most important factors influencing the preservation of the natural foundations of life. In our search for effective solutions, we should proceed on a scientific basis rather than being driven by seemingly plausible opinions

We want more, we're producing more, we're becoming more: The inhabitants of emerging nations are increasing their consumption, industrialized nations are intensifying their economic activities, and the world's population is growing. On the face of it, these are not bad developments. They testify to prosperity

and to people's pursuit of a good life. However, in past decades we have neglected an important consideration—possibly because in the past it was not as urgent as it is today: We will be able to live well only if we treat our planet well. And this is where we urgently need to do more.

In order to have a good life we also need to have healthy nutrition. But will we be able to provide almost ten billion people with healthy and sustainable nutrition in 2050? I'm convinced that we can do it. What's more, we have to do it! Globally operating companies like Evonik have a responsibility. It's not only a matter of key financial indicators; we have an obligation to help find solutions for global challenges. We're doing that with everything we've got, through technology and the know-how of our employees.

EXPLORING NEW FORMS OF FOOD PRODUCTION

By focusing on the opportunities offered by this technology, we are promoting a good life for the world's present population and for future generations. We envision this as the goal of our work. We have the courage to forge ahead with innovations, and we have the financial means to implement them. We must explore new approaches to the production and consumption of food. That's because concealed behind them is a significant lever for improving sustainability.

“Incremental improvements of the system will no longer be enough. We need a fundamental change of course in how we produce and consume food”

Food production and the animal husbandry that is associated with it are contributing to climate change. Meanwhile, people in many countries have unhealthy or inadequate diets or have lost a sense of proportion. Today the consequences of an unhealthy diet, which include overweight, are even more dramatic than those of malnutrition. Incremental improvements of the system will no longer be enough. We need a fundamental change of course in how we produce and consume food.

These connections are also clearly emphasized in the most recent reports published by scientists and governmental organizations. All of these experts agree that there are close interrelationships between nutrition, health, and sustainability. Health-conscious nutrition and sustainable food production are the keys to a good future on earth.

Our approach to these issues is not helped by dogmas or hasty conclusions. Only scientific findings provide us with the foundation of facts that we need in order to make good decisions. Are these findings always clear-cut? Of course not. That’s already obvious in the debate concerning the most effective method of food production. Is organic food production always good? In scientific terms, things are not that simple. Many standards for organically produced food dictate rules for the composition of animal feed that would lead to more resource consumption and significantly greater emissions of greenhouse gases and nitrates than the animal feed produced by conventional farming.

That also applies to modern meat replacement products. Many people already regard them as a source of salvation that will sustainably cover our demand for proteins. However, their environmental footprint is often worse than that of protein derived from fish, poultry or eggs. For example, if we add specific amino acids to animal feed, chick-

ens, pigs, cattle, dairy cows, and fish can metabolize their feed more effectively. The available nutrients can then be adapted to the animals’ actual needs.

As a result, the animals require less feed, and the resources that would otherwise be needed for the cultivation of soybeans or other fodder crops are conserved. In 2018, the use of our amino acids in animal feed conserved a net total of about 62 million tons of CO₂ equivalents. That amount roughly corresponds to the total greenhouse gas emissions of Portugal.

When animals require less feed because they are metabolizing their feed more effectively, much less arable land is needed. In the Amazon region last summer, gigantic areas of this valuable ecosystem went up in flames because of the slash-and-burn method of clearing land—mainly for the cultivation of soybeans that are used to produce animal feed. The consequences for biodiversity are obvious. The global use of our concepts for animal nutrition can significantly reduce these consequences.

In addition, a forward-looking approach to animal nutrition leads to a much more efficient use of nitrogen. The overuse of nitrogen places a severe burden on our environment. Nitrates in groundwater, lakes that have passed the tipping point past which they cannot sustain life, and the algal blooms in coastal waters are clear signs of that. Moreover, microorganisms in the soil use excess nitrogen to generate greenhouse gases. Every reduction of nitrogen helps to relieve pressure on the environment.

WEEKLY MARKETS ALONE ARE NOT ENOUGH

All of these examples show that when the issue is how we are to produce healthy food in the future, we should not be focusing on what we believe in or what makes us feel

good. We need to proceed scientifically, precisely calculate the environmental footprint of foods and their production systems, and then make well-informed decisions. The question of how we can live in healthy and sustainable ways does not have simple answers such as sending consumers to the weekly market or to the nearest farm. The answer is far more complex.

At Evonik, through our decades of work we have gained such deep insights into the interrelationships in the production of animal proteins and into modern animal husbandry, and we have acquired so much know-how about animal and nutrition physiology, that today we are able to offer holistic solutions. The future of animal farming now bears the name of Precision Livestock Farming.

In the future we will utilize far more digital and connected technologies in agriculture, and we will use them to collect and analyze data in order to make production systems more efficient and effective. Healthy human nutrition begins with healthy animal nutrition. With the help of probiotics, we are making an important contribution in this area. We are convinced that antibiotics should not be used prophylactically to promote animal growth in animal farming. They should only be employed therapeutically in cases of illness. By applying state-of-the-art, non-invasive diagnostic methods we can also continuously monitor the state of the animals’ health and adapt the composition of their feed accordingly.

All of these developments make me optimistic. If we resolutely tackle negative developments while focusing on scientific facts in the process and utilizing technological innovations boldly and consistently, we will be able to feed even ten billion people in 2050 without any further overexploitation of natural resources. —

TREASURE FROM THE OCEAN

TEXT JULIA BORN AND MICHAEL STANGE



Omega-3 fatty acids play a major role in the health of human organs such as the heart, the brain, and the eyes. However, more than 80 percent of people lack an adequate supply of these nutrients. Evonik aims to close this gap by tapping innovative sources—while protecting the world’s oceans

Beef stew, sausage salad, and cream of chicken soup—when Apollo 11 set its course for the moon 50 years ago, its crew was well supplied with down-to-earth cooking. For the USA’s National Aeronautics and Space Administration (NASA), food transportation and preparation technology was uncharted terrain. The astronauts’ meals—portioned, partially freeze-dried, and packed in plastic bags—became edible only when mixed with water. That was the diet of Neil Armstrong, Buzz Aldrin, and Michael Collins during their eight-day mission.

But even back then, NASA’s goal was more ambitious: space expeditions lasting several months, and someday maybe even missions to Mars. One important question to be answered was how to provide astronauts with healthy nutrition during such missions. In the mid-1980s, NASA formed numerous research partnerships in search of “superfoods”—vital nutrients

that space expeditions absolutely needed to have on board. In the course of their research, the scientists looked at marine microalgae in the North Pacific Ocean—and found a food source that could play a crucial role in global nutrition in the future.

The strain of algae they discovered, *Schizochytrium sp.*, is one of the richest sources of the essential omega-3 fatty acids EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). These microscopic single-cell organisms feed on plant residues and metabolize them to produce large amounts of EPA and DHA—polyunsaturated fatty acids that protect the human heart, brain, and eyes and have a positive effect on emotional well-being. During a pregnancy, they have an especially important influence on the embryo’s neural development.

Human beings, like most animals, cannot produce EPA and DHA on their own. They must obtain these nutrients directly through their food, especially fatty →



Fish farms like this one in Norway require large amounts of fish feed containing omega-3 fatty acids



In Blair, Nebraska, microalgae grow in vats. The oil they produce is then extracted (top photo) and processed to make fish feed

fish such as sardines, mackerel, and salmon. Plant-based oils such as rapeseed and linseed oil also contain an omega-3 fatty acid, in this case alpha-linolenic acid (ALA), but human beings can only transform this acid into EPA to a very limited extent.

The Food and Agriculture Organization (FAO) of the United Nations recommends that people cover their need for the omega-3 fatty acids EPA and DHA by eating fish once or twice a week in addition to using plant-based oils. According to recent scientific studies, we need to consume up to 500 milligrams of EPA and DHA per day. A blood test can reveal whether an individual

has sufficient reserves of omega-3 fatty acids by measuring the fatty-acid content of the cell membranes of red blood cells. A ratio of eight percent or more is ideal.

Only eight percent of people in the world reach this value. Most of them live in Norway, Japan, or Greenland, where people traditionally eat lots of fish. “In many Western countries, the EPA and DHA values of a large proportion of the population are too low,” says Clemens von Schacky, who heads the Preventive Cardiology unit at the clinic of the Ludwig-Maximilians-Universität München (LMU Munich). In these countries, industrially processed food dominates most people’s diet, and fish is seldom served. North America is just as undersupplied with omega-3 fatty acids as the UK and Germany. “Low levels of EPA and DHA are associated with numerous health problems, including shorter life expectancy, cardiovascular disorders, cognitive impairment such as attention deficit hyperactivity disorder (ADHD), and major depression,” says von Schacky, who developed the omega-3 blood test together with the US scientist Bill Harris.

STRESSED-OUT FISH STOCKS

In spite of the fatty acids’ importance for nutrition, it’s hard to maintain an adequate supply of them. In order to supply seven billion people with 500 milligrams daily, a total of 1.27 million tons of EPA and DHA would be needed. But if we add up all the sources of omega-3 fatty acids—rapeseed, walnuts, and fish—

only between 400,000 and 800,000 tons would be available, depending on the scenario we use.

Most importantly, the world's fish stocks are already stressed out today. Aquaculture could help to close the supply gap—but only if it is operated sustainably. Salmon in particular can play a major role. This silvery, shimmering predatory fish is one of the richest sources of omega-3 fatty acids for human beings. One hundred grams of salmon can contain about 2.5 grams of EPA and DHA.

Wild salmon prey on smaller fatty fish such as sardines, anchovies, and herring, which in turn like to feed on krill. The krill feed on algae that produce omega-3 fatty acids. This is the route taken by the EPA and DHA that end up in salmon stomachs. In aquaculture, this popular food fish is fed with pellets containing fish meal and fish oil that is rich in omega-3 fatty oils.

This method is reaching its limits. About 16 million tons of wild fish are caught annually in order to be processed into five million tons of fish meal and one million tons of fish oil. In other words, two kilograms of wild fish are needed to produce one kilogram of salmon.

MICROALGAE FROM THE VAT

The world's oceans already reached their limits a long time ago. According to the FAO, more than 60 percent of the world's fish stocks are reaching their limits, and 30 percent are even considered to be overfished. Only about ten percent are still in a healthy condition. Today the fish stocks have been so decimated, and the price of wild fish has increased to such an extent, that the fish oil in the feed for aquaculture has largely been replaced with plant-based oils. And plant-based oils provide no EPA or DHA. As a result, the omega-3 content of salmon has already decreased by half in the last ten years. Salmon is providing less and less of the substances that make it so nutritious for human beings. In addition, the limited amount of available fish oil is slowing down the growth of aquaculture, and thus the overall availability of fish.

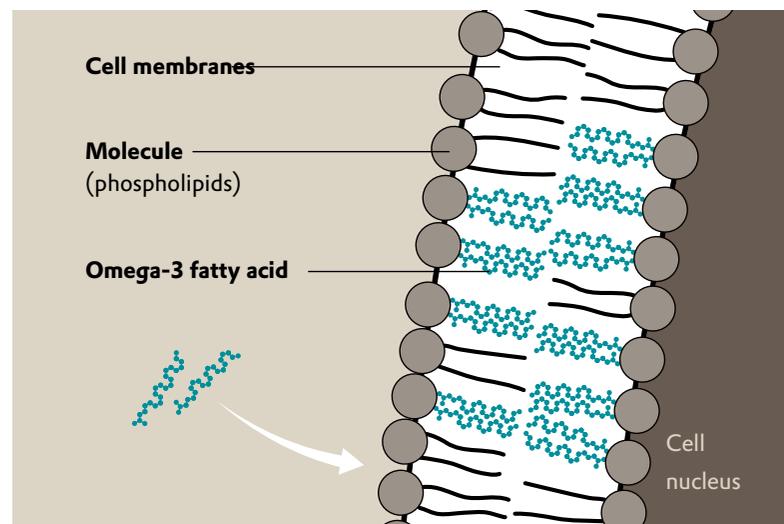
How can this supply gap be closed without putting further pressure on the oceans through industrial fishing? Researchers at the Evonik Group and the Dutch company DSM addressed this question by following up the findings of the NASA researchers who discovered the marine microalgae. Why not shorten the food chain and use this North Pacific algae strain to create an innovative and sustainable source of omega-3 fatty acids?

This was successfully accomplished for the first time on an industrial scale in a town located more than 2,000 kilometers from the North Pacific. In Blair, Nebraska, an ocher-colored algae brew is sloshing around in the huge vats. It's the result of several years of work by Veramaris, a joint venture of DSM and Evonik.

Together, the researchers developed a fermentation process that produces EPA and DHA directly from the microalgae. The product is an algae oil with a more than 50 percent content of EPA and DHA. The percentage in fish oil varies between 14 and 28 percent, depending on the season and the fishing zone. "Our algae oil is the answer to the industry's demand for a sustainable source of omega-3 fatty acids," says Veramaris CEO Karim Kurmaly. "One kilo of our product contains the same amount of EPA and DHA as 60 kilos of fish." →

How omega-3 fatty acids work

Once they have been absorbed by the body, the omega-3 fatty acids are incorporated into cell membrane as essential elements. Cell membranes contain molecules called phospholipids on their inner and outer surfaces. The omega-3 fatty acids diffuse into the phospholipid molecules, thus altering the fluidity and activity inside the membrane. They do this by producing various signaling molecules that in effect tell the body's genes what proteins to produce. This results in a whole spectrum of effects inside the human body. Omega-3 fatty acids improve blood flow, reduce blood pressure, and have a positive effect on blood lipid levels by reducing the levels of cholesterol and triglyceride. They also have a beneficial effect on the immune system: They serve as the base materials for eicosanoids (signaling molecules similar to hormones), which influence the body's inflammation and immune responses.





“Our algae oil production from Blair provides as much EPA and DHA as 1.2 million tons of wild fish”

KARIM KURMALY, CEO OF VERAMARIS

In order to produce this precious oil, the researchers must first propagate the algae cells—that is, get them to grow. For that, they need a nutrient fluid that contains various macroelements (such as nitrogen, phosphorus, potassium, and calcium), trace elements, and vitamins. The algae cells also need oxygen for respiration, as well as a sugar solution based on cornstarch as a source of energy and carbon. The algae brew stays in the fermenters for about a week. By that time it has generated so much oil that it can be extracted from the algae cells. Using a specially developed processing method, the researchers separate the oil from the watery fermentation fluid. The challenge lies in extracting extremely pure oil while keeping losses to a minimum and preventing the end product from going rancid.

THE AIM: FISH FEED WITHOUT FISH OIL

After the algae oil has been pumped into huge tanks, it is transported by truck and ship to the feed producers. Algae oil from Blair can cover about 15 percent of the worldwide salmon breeding industry’s demand for EPA and DHA. “In order to produce this amount, 1.2 million tons of wild fish would have to be caught annually,” says Kurmaly. The volume of fish that is spared in the world’s oceans thanks to this method is greater than the total annual fish catch in the Mediterranean Sea.





How much would you like? In countries where people eat lots of fatty fish such as mackerel and salmon, there's no omega-3 fatty acid deficiency

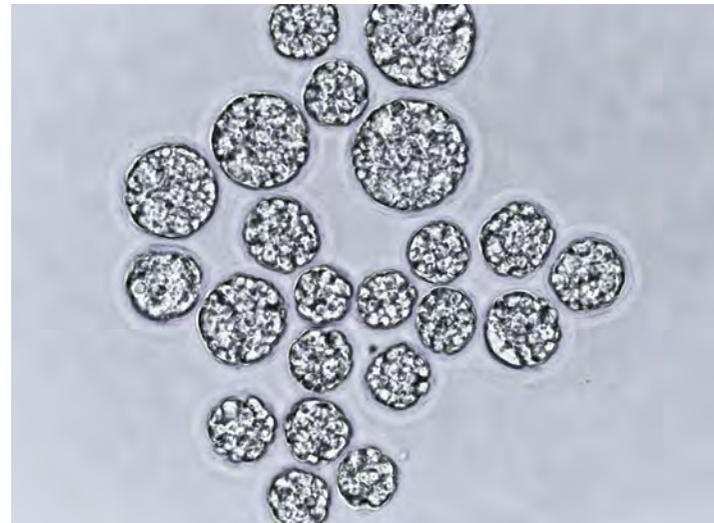
The algae oil that salmon like so much will soon be available to other kinds of fish as well. In the years ahead, Veramaris will supply this product to fish farms that raise trout, gilthead, bream, and shrimp. The ultimate aim is to one day produce fish feed for aquaculture that contains no fish oil at all.

In parallel, Evonik is using a second method to address the worldwide shortage of omega-3 fatty acids. People who don't want to, or can't, eat fish twice a week have the option of covering their need for omega-3 fatty acids through dietary supplements. Fish oil capsules dominate the dietary supplement market in drug stores and pharmacies.

ONE TABLET INSTEAD OF TWO CAPSULES

In order to also use the limited resource of fish oil in dietary supplements as efficiently as possible, Evonik has developed a method to improve the uptake of omega-3 in the human body. "This way people will need to consume less fish oil in order to get the same effect," says Christopher Studte, who is responsible for New Health Ingredients at Evonik's Health Care Business Line.

Evonik's second-generation dietary supplement is called AvailOm®. It's a powder that can be compressed into small tablets that are easy to swallow and are more easily tolerated by consumers. The researchers have combined omega-3 fatty acids with the essential amino acid lysine to form a complex. The powder can be processed into tablets or hard capsules on a large scale and contains at least 45 percent EPA and DHA. "That's a bigger percentage than that of any other powdered product on the market," says Studte. "One single small tablet provides the same effective uptake of omega-3 fatty acids as two big fish oil capsules."



Under the microscope: *Schizochytrium sp* algae

This product's effectiveness is due to its special composition. Unlike conventional fish oil capsules, in which the omega-3 fatty acids are present as esters, AvailOm® makes them directly available as a fatty acid-amino acid complex. The body does not have to convert the components of the tablet. "As a result, the body can absorb the EPA and DHA between three and four times more effectively," says Studte. "AvailOm® is effective even if it's taken on an empty stomach or as part of a low-fat diet."

Today the omega-3 fatty acids in AvailOm® still come from fish provided by certified, sustainable fisheries. But by the end of this year, a product based on algae oil will also be available on the market—to help protect the oceans and their denizens. —

BERRY POWER

TEXT NADINE ALBACH





Hunting and gathering: Bilberries are extremely popular in Scandinavia

As our society ages, the importance of a healthy lifestyle is growing. Nutritional supplements contribute toward mitigating deficiencies in our daily diet. Evonik is also developing new products in this area

Sweden—for Norwegians, their neighbors are arch-rivals. Especially when it comes to sports. Nevertheless, Sjur Svaboe has a photo of Swedish cross-country skiers from the 2006 Olympic team hanging on the wall of his office on the edge of Sandnes, a port city in southern Norway.

Nearly 20 years ago, Svaboe worked with the University of Bergen to develop the manufacturing process for MEDOX®. In 2016, Evonik bought the MedPalett company, which makes the nutritional supplement in Sandnes. MEDOX® contains anthocyanins—plant pigments from bilberries and black currants that promote heart health, blood circulation, and physical well-being (see info box on p. 40).

So why the picture of the Swedish athletes? If you look closely, you can see that the five athletes are holding cardboard boxes up to the camera—boxes with the word MEDOX® printed on them. Svaboe smiles and shares what is presumably one of his favorite anecdotes: “Usually, you could wake Norwegian cross-country skiers up in the middle of the night and have them ski backwards—they’d still beat Sweden.” But at the →

“Many illnesses are caused by poor nutrition”

SJUR SVABOE, THE INVENTOR OF MEDOX®



True Blue

Anthocyanins are secondary plant substances that can be found in eggplants and blueberries, for example. The name is derived from the Greek words *anthos* (flower) and *kyáneos* (dark blue). Inside plants, they protect DNA, sugar, and proteins from ultraviolet radiation. They also attract insects and other animals that help the plant propagate itself.



The deep-blue berries are compressed. To keep the concentrated mass fresh, it is frozen before being processed

2006 Olympic Winter Games in Italy, he pointed out, the team struggled with a performance slump—and with a starting advantage for the Swedes. The Swedish team doctor had recommended that they take MEDOX® to stay in good condition. “I sent them 200 free packages,” the 76 year old recalls. The result? The Swedes defeated the Norwegians—who were the clear favorites—in the women’s and men’s team sprint events.

Supplying the human body with essential nutrients has become a lifetime preoccupation for Svaboe, who once studied mathematics. “The roots of many diseases, like arteriosclerosis or diabetes, lie in improper nutrition,” he says. That society is slowly rethinking these issues is evidenced by how the global market for nutritional supplements has developed, generating sales of over €300 billion in 2018.

The more important the market, the louder the criticism of its products: Anyone looking up the term “nutritional supplements” online will quickly find many articles denouncing effects that don’t scam and materialize. The idea is put forward again and again that healthy people with a balanced diet and a health-conscious lifestyle do not need to take nutritional supplements.

“That’s true in theory,” says Dr. Laura Headley, a nutrition scientist at Evonik. “In a perfect world, we’d all have perfect diets.” But what about people who do not eat fish twice a week? Or people who live in a country where the sun barely shines in the winter and, as a result, lack sufficient vitamin D? Plus, every human body has to be considered individually, as Headley points out. Nutritional supplements can help offset any deficits, she adds.

An awareness of the importance of preventive health care has grown over the past several years—not least because people are growing older. The health of the world’s population since the early 1990s has been investigated in a study prepared by Harvard University, the World Health Organization, and the World Bank entitled “Global Burden of Disease.” One of the study’s findings is that our chances of reaching old age are higher than ever before: life expectancy around the world grew from around 66 to 73 years between 1990 and 2017. That does not necessarily mean that quality of life has improved, however: The study showed that people are healthy for only slightly over 63 of those 73 years.

COUNTERACTING MUSCLE LOSS

As age increases, so does the likelihood of chronic disease, as well as cognitive and physical impairments. At present, for example, 50 million people worldwide suffer from age-related muscle loss. Known as sarcopenia, the condition can lead to problems such as loss of strength, increasing frailty as well as susceptibility to falls. The European Working Group on Sarcopenia in Older People fears that the number of affected individuals could rise to over 200 million by 2060.

Physical exercise and optimized nutrition are considered especially important for keeping sarcopenia in check. One focus of nutrition science until now has been on essential amino acids and their importance in building muscle. Some amino acids can only be obtained through the diet, and nutritional supplements such as leucine, which belongs to the group of branched-chain amino acids (BCAAs), are intended to mitigate that deficit, says Headley. The nutrition scientist then notes, however, that after being supplied with nutrients the muscle naturally undergoes a process of breakdown and synthesis again. This process releases ammonia, which can promote fatigue and stresses the brain and kidneys.

Strengthen muscles or protect the kidneys? Evonik hopes to resolve that dilemma with MYOLUTION®, a nutritional supplement that is soon to be launched on the US market. The mixture of three branched-chain keto acids (BCKAs) has a similar impact on muscle development as BCAAs. The product does not contain any



nitrogen that can be converted to ammonia, however (see box on p. 42). “The combination is expected to help support muscle synthesis and reduce stress on the brain and kidneys,” says Headley.

Evonik’s Health Care Business Line has a great deal of experience in manufacturing BCKAs for the pharmaceuticals industry—its core competencies include not only chemical synthesis routes but also fermentation and crystallization processes. MYOLUTION® makes the company one of the first manufacturers to offer branched-chain keto acids in a food product.

In addition to healthy aging, another issue that is increasingly capturing the public imagination is that of good nutrition early in life. The Global Burden of Disease study brought to light the fact that more than half of all deaths worldwide can be traced to risk factors associated with lifestyle: hypertension, smoking, high blood

At MedPalett, the anthocyanins from the berries are carefully concentrated. Before being dried, they form a thick syrup



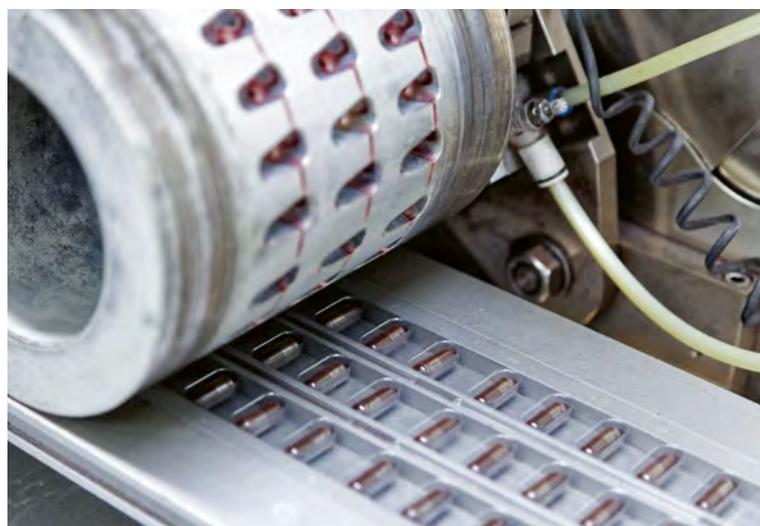
The finished MEDOX® capsules are packed and shipped directly in the production plant at MedPalett in Sandnes

sugar, and excess weight. Improper nutrition plays a key role here. In many countries, people consume too many sugary beverages, processed meat, and salt—while whole-grain products, nuts, fruits, and vegetables are not on the table often enough.

Poor nutrition can often be remedied with a change in eating habits; certain nutrients such as omega-3 fatty acids can also be consumed in the form of a nutritional supplement. In AvailOm®, Evonik has succeeded in concentrating the effective amount of essential fatty acids in two large fish oil capsules into one small tablet (see article on p. 32).

The market is increasingly oriented toward knowledgeable consumers. According to a study conducted by the Leibniz University of Hanover, the majority of people who take nutritional supplements are well informed and use the products responsibly. Monitoring health status and personal performance using a smartphone app or fitness tracker is an accepted part of life for many—especially in China. The nutritional supplement markets in the People’s Republic and in Japan are among the largest in the Asia-Pacific region. Nearly half the population of Japan used nutritional supplements in 2016. High population density and growing income have caused demand to increase, says BCC Research, a market research institute in the United States.

The largest sales market, however, is North America, where, according to the Council for Responsible Nutrition, 75 percent of all adults in the US regularly took nutritional supplements in 2018. In Germany, by comparison, that figure is roughly 25 to 30 percent. The trend toward DIY health care is fostered by the American health system:



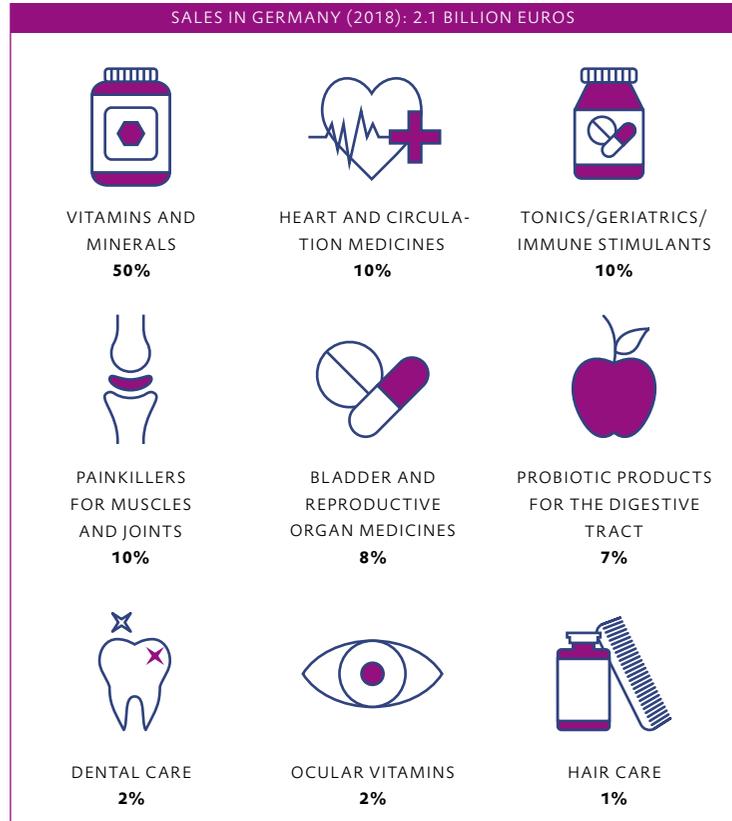
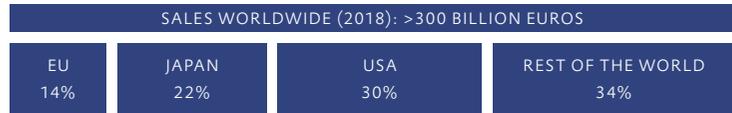
A Gentle Alternative

From a nutritional perspective, branched-chain ketoacids (BCKAs) correspond to branched-chain amino acids (BCAAs). Both substances help to form proteins in the body and thus promote muscle development. BCKA is transformed into BCAA in the body. Because ketoacids do not contain nitrogen, there is no formation of the ammonia that could cause health problems.

Physical Training

Where nutritional supplements do their work

Source: KPMG 2015, IQVIA 2019, own calculations—figures rounded



The percentages quoted are approximate

While 90 percent of all Americans have health insurance, coverage of services is minimal, leaving many unable to pay their medical bills in the event of a severe illness. Interest in staying healthy is correspondingly high.

PRODUCTS WITH A PROVEN EFFECT

But do nutritional supplements really do what they promise? Because they are legally classified as food, they are not subject to government approval the way medications are. Directives such as those in the EU, with special regulations regarding ingredients and labeling for nutritional supplements, would provide a reliable framework, Headley believes. “Evonik only has products in its portfolio that have been scientifically demonstrated to improve human health.”

The health effects of anthocyanins from dark berries, for instance—the primary component of MEDOX®—have thus far been investigated in some 20 independent, placebo-controlled, double-blind studies at university hospitals. “These have shown that taking anthocyanins leads to lower LDL-C—so-called ‘bad cholesterol’—and increased HDL-C—‘good cholesterol,’” says Einar Bakstad, the research director at the Biolink Group, which included the MEDOX® producer MedPalett before the company was acquired by Evonik. “That’s particularly interesting with respect to cardiovascular diseases,” notes Bakstad, a professor at Norway’s University of Stavanger who teaches synthetic organic chemistry. The University of Stavanger is currently collaborating with Kings College London on a study investigating the influence of MEDOX® on dementia prevention. The thesis is that taking highly concentrated anthocyanins could slow down the development of dementia. The results are expected in 2020.

What makes MEDOX® special, says Einar Bakstad, is the multistage refinement process, which leaves the sensitive ingredients from the berries intact, in high concentration. The product from Norway is striking a chord: According to BCC Research, consumers are increasingly turning to natural ingredients in the conviction that these will deliver greater bioavailability with no side effects. “Nutritional supplements can help prevent risks,” says Headley. “It’s all about taking a measure of control over your life.” Just like those Swedish cross-country skiers who snatched the gold from the Norwegians in 2006. —

In the harsh climate of Scandinavia, the berries form many anthocyanins



Custom- made Meals

A stable blood sugar level is the key to a healthy life, says Professor Christian Sina. He's a physician who advocates for personalized nutrition plans that are tailored to match an individual's metabolism—yet require a minimum of effort

INTERVIEW **SONJA BAULIG**
PHOTOGRAPHY **DAVID MAUPILÉ**

Professor Sina, your analyses show that different individuals who are consuming the same foods react differently to them and end up with different levels of blood sugar. For example, some individuals have higher blood sugar levels after eating tomatoes, while others do not. Why is that?

We still can't explain that with one hundred percent certainty. But at least we do know that our intestinal microbiome—the millions of bacteria that live in our intestines—have a very big influence on the way we process the food we eat. Every individual has a different array of intestinal bacteria and therefore reacts differently to various foods.

Is that why you're advocating for personalized nutrition plans?

That's right. For years now, we've been asking, "What's the right diet for people in general?"—rather than "What's the right diet for me in my individual situation?" Having a specific diet is a bit like taking medication: Something that works well for one person may have no impact on another or may even have negative side effects. We can use data to find out what kind of diet is more beneficial for my individual metabolism or less beneficial. That way I can make informed choices.

Does this mean that the traditional rules about good nutrition are outdated?

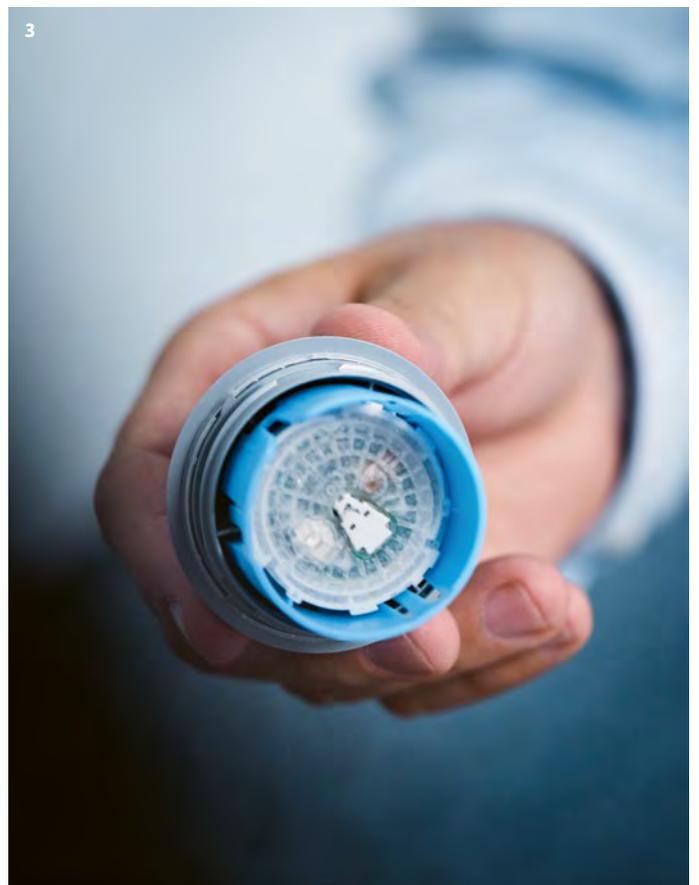
No, they're still valid. It's still important to have as varied a diet as possible and to consume an adequate amount of nutrients. The key factors are dietary fiber, trace elements, vitamins, and minerals—and large amounts of these substances can be found in vegetables. These factors are important for the proper functioning of the metabolism and the immune system. In addition, we should enjoy all the food we eat in moderation in order to avoid gaining weight. In other words, we should consume only as many calories as we burn. But that alone is not enough.

What kind of data do you collect for your analysis of metabolic processes?

In our "Million Friends" program, we can record the changes in an individual's blood sugar levels after food consumption over a period of 14 days. The recording is done by a small sensor attached to the upper arm. A thin filament measures the glucose content of tissue by monitoring the extracellular matrix between cells. We also use the information our test subjects provide in a questionnaire. All of this information taken together helps us to give individualized recommendations about diet. We now have about 2,000 participants all over Germany in our program. The youngest participant is 18 years old, the oldest is 82. →

Prof. Christian Sina, 43, is the Director of the Institute of Nutritional Medicine at the University Hospital of Schleswig-Holstein in Lübeck. An internist and gastroenterologist, he has focused on intestinal health for many years. In order to offer better nutrition-based prevention programs and treatment concepts, a team of physicians, bioinformaticists, system biologists, and nutrition researchers developed the “Million Friends” program at the Institute. The program’s participants measure their blood sugar levels and can adapt their diets accordingly. The program, whose name refers to the millions of intestinal bacteria, is operated by Perfood, a startup based in Lübeck. Prof. Sina sits on its scientific advisory board. He also advises Evonik on issues related to nutrition and food ingredients. Together with Evonik, he also monitors joint research projects focusing on intestinal health.





1 Research findings show that people react differently to the various constituents of their diets. These findings are the basis of a study conducted by Professor Christian Sina and his team. **2** About 2,000 men and women have been taking part in this study since the fall of 2018. The researchers in Lübeck are gaining more information almost every day. **3** The participants in the study wear a sensor on their upper arm. Inside the sensor is a thin filament that measures the glucose content of the subcutaneous tissue and transmits the measured values to a reading device.

Why is the blood sugar level so significant for our health?

It provides important indicators of the development of diabetes and other metabolic diseases, and possibly even for certain types of cancer. We also know that there's a connection between the blood sugar level and many other health problems, which range from migraines to inflammations in the abdominal region. We hope that in the future we can prevent these health problems more effectively and provide better therapies for precursor stages such as prediabetes if patients adapt their diet to their individual metabolism. This would also have a positive effect on the patient's general sense of well-being, because if our blood sugar level is stable we feel well-balanced, no longer get tired during the day, and are more productive in general.

However, many people find it difficult to change their eating habits.

Yes, they do. That's what we've learned from our daily work at the clinic, and we all know that about ourselves. Only a very few people manage to radically transform their individual diet over the long term. Nonetheless, if it's only a matter of small adaptations, there's a bigger chance of achieving sustainable success. The goal is to make an intelligent selection of the foods you like to eat. As a rule, you only have to adapt between five and ten percent of the food you eat in order to optimize your individual metabolism.

What does that mean in concrete terms?

For example, the data might show that an individual has consumed inadequate amounts of dietary fiber in the past. As a result, certain intestinal bacteria have stopped growing or multiplying, and that may be having negative effects on the person's metabolism. We can encourage this person to consume more dietary fiber. The time of day when you eat something also plays a role in your blood sugar level. One type of metabolic pattern metabolizes carbohydrates more effectively in the morning, another type in the evening. It would be advisable for the "morning type" to have a substantial breakfast and to compensate by avoiding carbohydrates at suppertime. For the "evening type," it would make sense to reverse this pattern.

What differences between metabolic patterns have you identified so far?

At the moment we're gaining more information almost every day, and as the data volume grows this data is becoming increasingly precise. We can determine how an individual reacts to proteins and fats. We can also find out how his or her blood sugar level reacts to different sources of sugar. That way we can tell whether potatoes, rice or pasta is a better side dish for that person. And we also know whether coffee has a positive or negative effect on a person's blood sugar reaction.

“The goal is to make an intelligent selection of the foods you like to eat”

Not everyone finds it easy to give up bread and rolls...

In many cases it helps to eat the roll with butter—in other words, a fat—or a source of protein such as quark or cheese. Both types of food can prolong the period of time the food stays in the stomach—and that prevents a steep increase of blood sugar. Our data shows that some people achieve stable blood sugar values by increasing their intake of fat, while others benefit from more protein. However, for about 20 percent of people, this modulation of blood sugar via protein or fat doesn't work at all. To improve their blood sugar level, they'd be better off having bread or rolls only on Sundays. Our test shows people which group they belong in.

What can the food industry learn from your research?

It can make its products better. For example, a cereals producer could use our findings to do something more effective than merely reducing its products' sugar content. It could offer three different variants of its product on the market: the original product, one with a higher protein content, and one with a higher fat content. Consumers of different metabolic types could choose the right cereal for maintaining a stable blood sugar level. That would be more healthy for consumers. Our goal is to make it as simple as possible for people to have a beneficial diet without any pressure or sets of rules.

Do you envision a future in which kitchen robots automatically prepare the healthiest possible meal for each family member?

Why not? Prototypes of such kitchens already exist. Our goal is to provide the kitchens of the future with recipes that are adapted to the individual metabolic types. That way, everyone will sit down to a custom-made meal. This is an approach that will revolutionize nutrition.

Have you changed your own diet on the basis of your findings?

I've given up eating bread, and I now eat oatmeal porridge for breakfast. If I do eat bread I have it with quark or cheese, because I'm a "protein type." In addition, I try to vary my diet as much as possible and to consume lots of dietary fiber. An important aspect of my diet is that I don't have to deny myself anything. I can put together my meals in line with my own food preferences. —

Between a rural idyll and urban modernity: Argentina is both a peaceful oasis and part of the pulsating heart of South America

Argentina owes its name to the fact that the first European explorers to reach this country were looking for silver, whose Latin name is *argentum*. Today this country is forging a golden future for itself

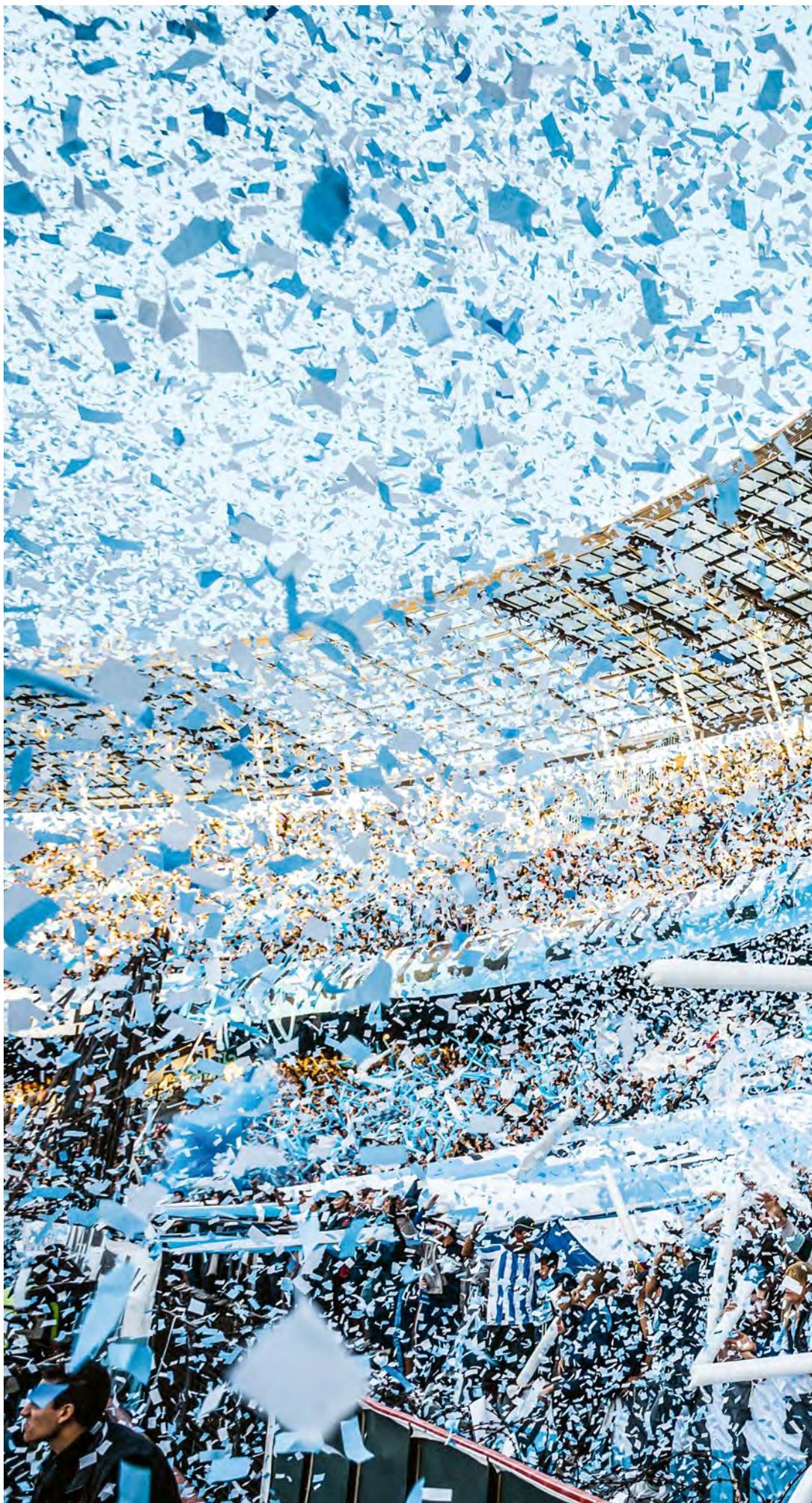
TEXT ANNA SCHRIEVER AND NICOLAS GARZ



■ Cattle breeding plays an important role in Argentina's culture and its economy. Steaks from Argentina are valued because of their top quality, which is due to the extensive grasslands on which the cattle graze. Argentinians enjoy their juicy steaks best of all *a la parrilla*—directly from the grill. And the best way to develop their intense flavor is to use a grill with a high-quality coating. Silikoftal® products from Evonik are binders that give grills and skillets positive qualities, such as especially good adhesion to aluminum and steel, high levels of heat resistance, and resistance to dishwashing detergents.



■ Argentina's heart beats for soccer. The national soccer team, fondly referred to as *La Selección*, won the World Cup twice, in 1978 and 1986, sparking ecstatic celebrations in blue and white throughout the country. Today the national team and its captain, Lionel Messi, are still thrilling soccer fans—for example, here in the Estadio Presidente Juan Domingo Perón in Buenos Aires. Comfortable seating is important too. And this is where chemistry plays a role: To ensure that the seats hold up as long as possible under the visitors' weight and the UV radiation of sunlight, the plastic in the seats includes an admixture of triacetoneamine derivatives.





The solitary 67.5-meter-high obelisk on the Plaza de la República rises high into the sky above Buenos Aires. Around it, traffic rampages along the Avenida 9 de Julio, which for a long time was the widest street in the world. Here and elsewhere, the country has been combating the environmental damage caused by traffic for a long time. A law passed in 2007 requires that gasoline contain a certain proportion of biodiesel. This was an important step in Argentina's transport policy turnaround, which Evonik actively supports. In Puerto General San Martín, the Group produces sodium methylate, which acts as a catalyst in the production of biodiesel made from renewable raw materials.





— The tango is characterized by the dancers' upright posture and extravagant movements. The Argentinian composer Enrique Santos Discépolo called tango “a sad thought that can be danced” —but it’s a sadness that brings joy to people all over the world. Since the end of the 19th century it has spread all over the world, and today it is recognized by UNESCO as part of the world’s intangible cultural heritage. Evonik cares for the material foundation of tango—a shining parquet floor—with VESTANAT® EP-EF 201. This environmentally friendly hybrid crosslinker gives wood coatings a high-quality appearance.

High altitudes, a warm climate, and a long winegrowing tradition: Vineyards such as this one in Cafayate in the northwestern province of Salta enjoy optimal growing conditions. Argentina is one of the world's biggest wine producers. According to the International Organisation of Vine and Wine (OIV), in 2018 the production volume of Argentina's wine industry increased by 23 percent to 14.5 million hectoliters. To prevent crop failures, winegrowers depend on products that protect their plants from pests and disease. Potassium bicarbonate from Evonik protects vines from mildew, for example. The advantage of this product is that it not only dries out the fungus but also fertilizes the plants.





A CLEAR FOCUS ON BUSINESS

Evonik's predecessor companies established themselves in South America's second-largest country as early as 1969. This was the beginning of a commitment that has lasted for decades. The last major expansion took place in 2013, when Evonik commissioned the production plant in Rosario. Since then, Animal Nutrition and Functional Solutions have been the Group's two focal points in Argentina.



The
2
locations have
60
employees.



GOOD INSIDE AND OUT

TEXT BERND KALTWASSER

A third of every kilogram of food we produce is thrown away or lost. The use of coatings and additives in packaging helps to curb the loss and waste of food

It's a staggering number: 1,500,000,000,000,000—1.5 quadrillion—kilocalories' worth of food is wasted every year between field and fork. In purely numerical terms, that would be enough energy to feed two billion additional human beings. The worldwide economic damage that is being caused by food losses and food waste totals almost US\$1 trillion per year. The careless way we deal with food is contributing to hunger and food shortages in developing countries and also accelerating land use and water consumption. If the loss of food were a country, it would occupy third place in the list of the biggest emitters of greenhouse gases.

The specific ways that foodstuffs are lost vary greatly, depending on the region of the world where the losses are happening. In the United States, an average family of four wastes food worth about US\$1,500 every year. The main reason for this is that the family buys too much food and ultimately does not consume all of it. By contrast, in countries like Nigeria and Benin several hundred thousand tons of food crops rot in the fields every year because the producers cannot harvest or process it on time. The economic damage caused by these losses in sub-Saharan Africa amounts to more than US\$4 billion annually.

The causes of food losses and food waste are extremely varied, and the approaches we need in order to solve these problems are equally diverse. In Africa, improved harvesting methods and expansion of the infrastructure are promising approaches, whereas in Europe and North America the greatest potential for success lies in sensitizing people to the consequences of their food purchasing behavior. Modern plastics can also make a positive contribution at every level of the food industry, ranging from food producers all the way down to the consumers.

GREENHOUSE FILMS: ADDITIVES FOR AN OPTIMAL CLIMATE

Greenhouse films can help food producers to ensure reliable and high-quality harvests. "These films have become an essential tool in the agricultural sector," says Uwe Kinzlinger, an applications engineer in the Silica Business Line at Evonik. "They create an optimal indoor climate, and as a result plants can be cultivated and fresh produce can be harvested all year round." To make sure that greenhouse films can optimally fulfill their function, manufacturers often use additives to create specific properties.

"If a small percentage of aluminum silicate is added during the manufacturing process, the film can keep heat inside more effectively. That makes it possible to maintain a higher temperature inside the greenhouse," Kinzlinger explains. The additive does not affect the film's transmittance, but the light is scattered and blurred to a somewhat greater extent. Depending on the climatic conditions and the location of the greenhouse, this can be a very desirable effect, because it means that sunlight is evenly distributed to every part of a plant.

If the plants in a greenhouse are exposed to strong direct sunlight, they can be damaged—especially if drops of water have gathered on the interior surface of the film in the form of dew and are concentrating the sun's rays like a magnifying glass. If this effect raises the temperature too far, the plants are subject to sunburn and heat damage. This results in discolored leaves, rotten fruit, and the death of young plants. To prevent this from happening, the greenhouse films can incorporate additives that contain surfactants, which reduce surface tension. As a result, instead of coalescing into individual droplets, water on the inside of the covering forms into a thin film that evenly scatters the sunlight.

FILM PACKAGING: ENSURING FRESHNESS BY AVOIDING CONDENSATION WATER

The longer the production and supply chains get, the more important plastic films will become as packaging for the secure provision of food. "The debate about single-use products made of plastic is being conducted at a very emotional level. People sometimes lose sight of the fact that plastics make a crucial contribution to protecting the quality of food and prolonging its storage →

life,” says Pavel Belik, Head of the Compounding Product Segment in Europe, the Middle East, and Africa. For example, unpackaged meat spoils after about four days. However, if it is vacuum-sealed, it can stay fresh for as long as 30 days.

In developed regions in particular, the right packaging is an important means of reducing waste while foodstuffs are transported to supermarkets and from there to consumers’ refrigerators. The anti-fogging additives that are employed in greenhouse films can be used here as well. Variants of these additives that are authorized for direct contact with foodstuffs ensure that only small droplets of water that easily evaporate form inside the packaging. That prevents the formation of condensation water, which leads to the spoilage of the packaging’s contents. “This packaging makes the hygienic handling and transportation of many foodstuffs possible in the first place,” says Belik.

ACTIVE PACKAGING ENSURES THAT OXYGEN DOESN’T STAND A CHANCE

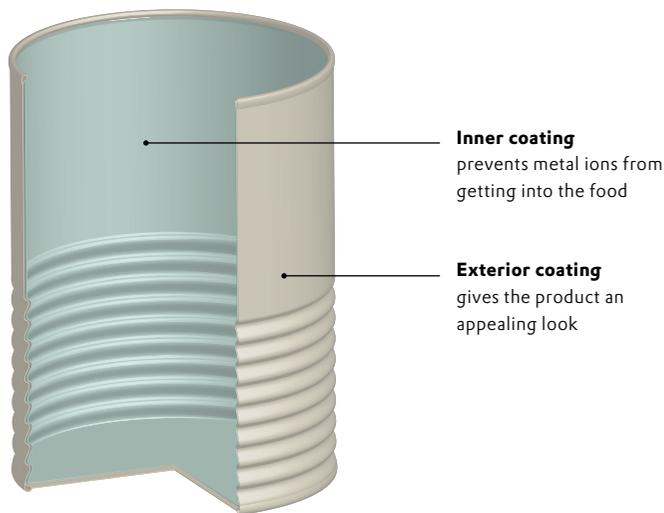
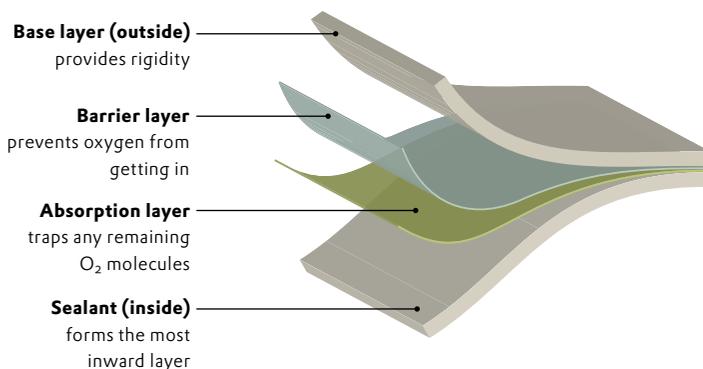
Traditional packaging is merely a passive covering that protects food by serving as a non-reactive or minimally reactive barrier against environmental influences. Active packaging, by contrast, creates a protective interior environment and thus keeps its contents fresh. Products such as meat and sausages, nuts, and beverages react sensitively to oxygen, which is present in residual amounts even in shrink-wrapped packages. Through the reaction with oxygen, vitamins lose their health-promoting effect and fats become rancid. Oxygen also makes it possible for bacteria and mold to grow.

As a result, many foods are now packaged in a protective atmosphere in order to keep their oxygen content low. In North America and Japan in particular, food producers use small bags full of iron compounds to further reduce the oxygen content inside packaging. However, there are limits to the effectiveness of this process: It doesn’t work for very dry products, for example. Moreover, consumers sometimes eat the contents of the little bags because they mistakenly think they contain herbs. Although other types of oxygen absorbers can protect the product, they turn an unsightly shade of yellow over time.

“We have developed a polymer-based oxygen absorber that can be directly integrated into the packaging material. It captures the remaining oxygen molecules and remains transparent,” says Pedro Vazquez Toran, who is responsible for the active packaging business at Evonik. Over the past three years this additive, which is called VISSPARENT®, has passed all the stages leading to approval by the US Food and Drug Administration (FDA). Initial talks have already taken place with potential customers and processors.

Layer by layer

It’s not apparent that high-tech materials are contained in today’s packaging. Additives (in films) and coatings (in cans) ensure the effective protection—an increased durability—of the food they contain.



THE INTERIOR COATING OF CANS: COATINGS FOR A LONG STORAGE LIFE

Along with film packaging, tin cans are among the most important types of food packaging. The high-quality sheet metal that is used for this purpose is lightweight and non-fragile, and also offers airtight protection against external influences. It enables many foodstuffs to remain edible for several years.

Metal cans are also great for recycling. Their recycling rate is over 90 percent—one of the highest in the packaging sector. The scrap metal is pressed and melted down. In the process, paints, coatings, and other addi-

tives are incinerated, while the can is turned into crude metal that can be reused in a cyclical process.

To make sure that acidic foods and other contents that could corrode the metal remain edible for a long time, the cans must be coated inside. A very thin coating prevents the can's contents from interacting with the sheet metal and keeps metal ions from getting into the canned food. Only a small amount of the coating—between eight and ten grams per square meter—is sufficient. Depending on the size of the can, that means about three grams per can.

“What makes it challenging to formulate the coating is the way the cans are produced,” says Thorsten Brand, an applications engineer at Evonik's Coating & Adhesive Resins Business Line. First, the coatings are applied to flat ribbons of metal or steel plates and hardened in a furnace. Only then are the coated metal sheets turned into can bodies and can lids. “The coating has to be sufficiently flexible. Otherwise, it will tear and peel off,” says Brand. After the filling process is completed,

the can is ready for the next stress test: sterilization. To lengthen the storage life of the canned food, the cans are treated in the sterilization chamber under pressure at a temperature of 130°C. Only if the coatings have also weathered this step without any damage are the cans ready for sale. High-polymer polyesters and cross-linkers ensure that the coating remains flexible but is nonetheless durable. As a result, the cans can withstand mechanical deformation as well as the subsequent hot sterilization treatment.

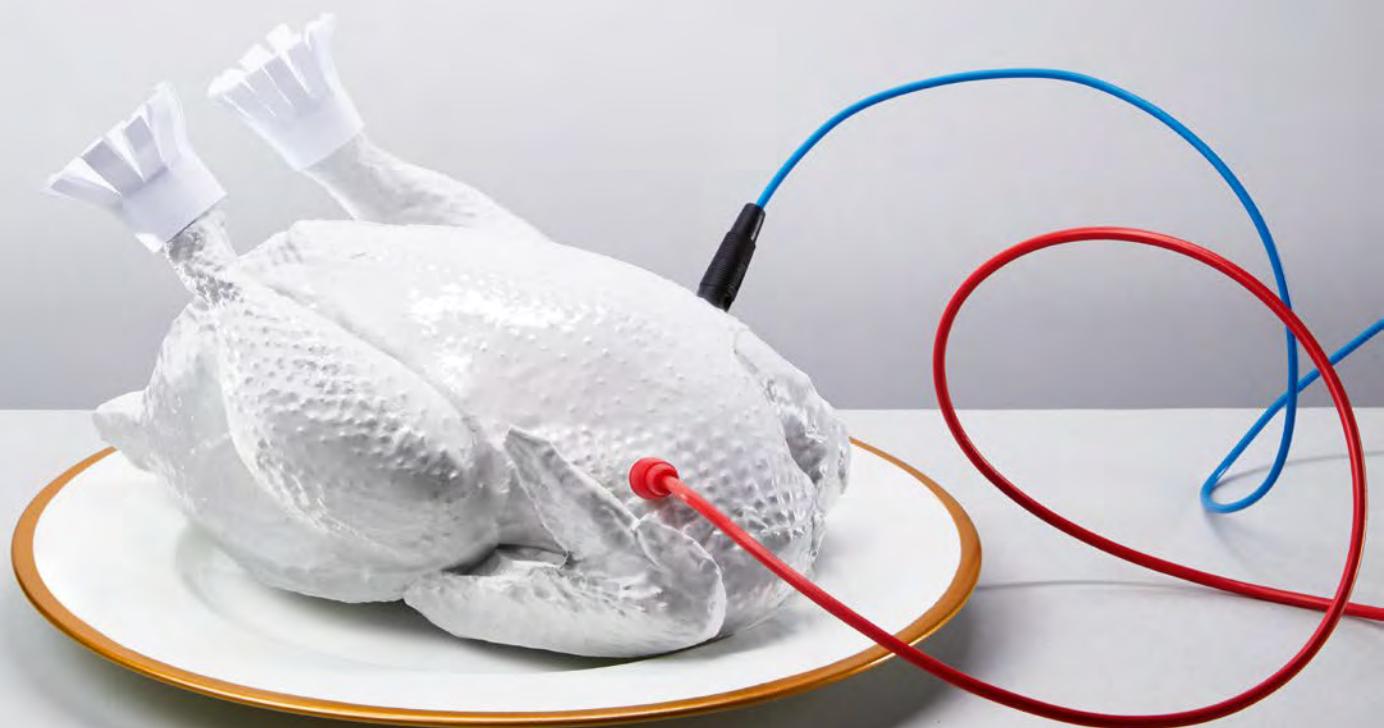
The food industry can only be efficient if food is kept fresh longer. Even today, the world can no longer afford to waste and lose a third of its food. This will be an even graver concern in the future. To keep around ten billion people fed in the year 2050, an additional six quadrillion kilocalories will have to be made available annually. If we succeed in cutting worldwide food wastage in half by then, part of this gap would already be closed—without putting any further strain on the soil and without limiting food consumption. —

Additives improve the properties of greenhouse films in order to ensure the optimal growth of plants



TEXT BJÖRN THEIS

EAT MORE AIR!



A burger made of hydrogen, carbon dioxide, and nitrogen? The Finnish company Solar Foods plans to serve us such a creation pretty soon

But as everybody knows, you can't live on air alone. Because people need to eat food every day, they've been getting their meals from fields and domesticated animals for thousands of years. However, farming consumes a lot of natural resources, burdens the environment, and often requires hard work. Besides, the produce isn't very diverse. For example, around 60 percent of the calories and proteins that human beings get from cultivated plants come from just three crops: corn, rice, and wheat. Proteins might soon be served that don't necessarily come from a farmer's field. For example, the Finnish company Solar Foods promises to deliver a completely new protein-rich food that only needs electricity, air, water, and a strain of bacterium to produce.

A PROTEIN-RICH POWDER MADE BY BACTERIA

The startup, which was founded in 2017, calls its new food Solein. It is meant to provide a solution for the future feeding of humanity. The food-tech company produces a powder that looks and tastes like wheat flour. Solein is produced by means of electrolysis in which electricity—preferably from renewable resources—is passed through water to generate hydrogen. This hydrogen is then combined with CO₂, which Solar Foods extracts from the air. Added to this are a few other nutrients such as sodium as well as some nitrogen and a few vitamins. This mixture is then fed to a strain of bacterium that metabolizes it to excrete Solein as an end product. According to Solar Foods, this powder consists of about five to 10 percent fat, 20 to 25 percent carbohydrates, and 50 percent protein. At its market launch, Solein is scheduled to cost around five euros per kilogram. It can serve as the basis for bread, smoothies, pasta, and yogurt.

The founders of Solar Foods hope that their protein will also be used in the vegetarian burgers offered by Beyond Meat and Impossible Foods. These companies

currently get the proteins for their meat-like patties mainly from peas, potatoes, and soybeans. However, Solar Foods has even more far-reaching ideas: The startup is convinced that its product can one day be processed in 3D printers so that food could be given a variety of textures.

ZERO-EMISSION FOOD

At the moment, the company only has a pilot plant near Helsinki, which produces one kilogram of Solein per day. According to Solar Foods, the first commercial factory will go into operation in 2021 and produce 50 million meals per year. The company plans to rapidly expand this capacity so that its fermenters will be able to produce two billion meals in 2022.

This manufacturing process could have a fascinating future, because it would enable proteins to be produced at any location that has access to water and electricity—no matter whether it is in the Arctic, in the desert or on the moon. What's more, this kind of food production conserves resources. Solar Foods claims that only ten liters of water are needed to produce one kilogram of Solein. Producing the same amount of protein from soybeans requires 2,500 liters of water, while doing so from meat consumes around 15,000 liters. In addition, this kind of production doesn't generate emissions as long as the electricity comes from renewable sources and the carbon dioxide is extracted from the air.

Even though we don't yet know how Solein spaghetti will taste, the startup's concept addresses a global challenge that we are currently facing. Those are good reasons for the Foresight team at Creavis (Evonik's strategic innovation unit) to take a closer look at this power-to-food approach. It has great environmental and economic potential. The technology provides a future-oriented answer to the question of how the world's population can be fed in the future. Who knows? Maybe it will be possible to live on air alone—supplemented by a few bacteria. —



Björn Theis heads the Corporate Foresight department at Evonik's innovation unit Creavis. In addition, he regularly writes a column for *Elements*: elements.evonik.de

IN MY ELEMENT



“I’m a 14-year-old Chemistry Student”

Alexander Mottl is probably Germany’s youngest chemistry student. Although he’s only 14, he has been studying at Ruhr University Bochum for two semesters. The University’s special program for tenth to twelfth-graders has made an exception for Mottl, who is in the eighth grade.

LOG ANNA SCHRIEVER
PHOTOGRAPHY ROBERT EIKELPOTH

Gallium is a very rare metal that already melts at 29.8 degrees Celsius. What especially fascinates me about it is that if you take a piece of gallium in your hand, it becomes a silvery-white mass that flows between your fingers. It stays liquid even after it has cooled off again. To make it solid again, you have to add a seed crystal or cool it off even more.

In order to learn more about rare elements such as gallium, I’ve been studying chemistry for two semesters at the Ruhr University in Bochum. I’m one of about 100 participants of this special program—and the only one who’s studying chemistry. At the same time, I’m attending eighth grade at a comprehensive school. At 14, I’m by far

the youngest student in the lectures. The first lecture I attended was called “General Chemistry.” I did feel a bit weird when I first saw this huge auditorium filled with more than 100 students. But I’m not bothered by the fact that my fellow students are much older than me. I actually understood everything the instructor said right away. The only things I didn’t know yet were some of the formulas.

Highschoolers can study any subject at the university in Bochum. When people ask me why I’m studying chemistry, I tell them I can turn my room at home into a chemistry lab simply by opening the closet. It’s full of beakers, test tubes, a burner, chemicals, and an entire distillation unit. I started to con-

duct experiments at home a few years ago. I began to take chemistry classes in seventh grade, but they were boring. The lectures at the university are much more interesting.

Normally, the special program at the Ruhr University Bochum is targeted at high-schoolers in grades 10 and up, but they made an exception for me. I go to the university three days a week. The topics taught there include analytical chemistry, organic chemistry, and the statistical evaluation of data. I have to make up the classwork that I missed at school. Like the other college students, I take exams at the end of each semester. The only drawback is that I can’t earn a bachelor’s degree until after I receive my high school diploma.”

Masthead

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elements.evonik.de

To eat is a necessity, but to eat intelligently...

...is an art, according to the French author François de la Rochefoucauld. This dualism between necessity and lifestyle still characterizes our nutrition today. On one hand, we need to provide enough food for a growing world population—on the other, we need to produce food that is good for human beings and the environment as well.

This issue of *Elements* examines these major challenges of our time from various perspectives. It also shows how future-oriented innovations are making our diet healthier and more sustainable and—just as importantly—enhancing its appeal.

3/2019 **Nutrition**