

ELEMENTS

Research. Knowledge. The future.



A Bright Future

2/2019

**What Will the World Look Like in 2040? Evonik Creates Scenarios
for the Future of the Specialty Chemical Industry → p. 10**

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The future

The time following the present

The future Various concepts of the future have developed over the course of history. Until the end of the ancient world, a cyclical view of history predominated. Instead of expecting progress, people believed in the eternal repetition of the past. In the Middle Ages, people conceived of the future as the descent of God from heaven. The Renaissance brought with it a rational concept of the future, marked by the works of Leonardo da Vinci. Powered by the Enlightenment, modern thought in the West is still shaped today by the belief that the future develops linearly and brings progress.

Renaissance: The epoch of European culture in the 15th and 16th centuries, at the boundary between the Middle Ages and the modern era.

Leonardo da Vinci (1452–1519): Italian painter, sculptor, architect, and engineer



DEAR READERS,

Today no one can safely say what the world will look like in 2040. But it does seem certain that between now and then there will be massive shifts in the areas of politics and economics. Digitalization, climate change, and the rapid growth of the world's population are confronting governments and companies with problems for which there are still no solutions today.

For innovative companies such as Evonik, this transformation is bringing both opportunities and risks. That's why the Group has brought together a team of futurologists who are depicting far-reaching global developments in specially developed scenarios and anticipating their effects on industry. Of course these researchers too don't know what our world will look like in 2040. Nonetheless, they present five of their scenarios in this issue (page 10).

After the European elections, the politicians in Brussels are also being confronted by an uncertain future. What's going to happen to the EU? And how can the next generation of Europeans be inspired by the concept of Europe? We put this question to the Italian futurologist Fabiana Scapolo, who works for the European Commission. She has some clear ideas on how to create a better Europe (page 22). Evonik CEO Christian Kullmann also has some ideas about the matter. In his comment (page 28), he writes about what the results of the European elections mean for industry and what priorities need to be set in Brussels.

When we think about coatings—paints, varnishes, lacquers and so on—most of us, depending on our personal inclinations, associate them with cars, fingernails or boots. Gaetano Blanda and his team think of COATINO™. He's a specialized digital lab assistant who understands human speech. If you ask him a question, he can even give you practical tips about developing formulations for new coatings. He's always friendly, never tired, and terribly competent. See for yourself! (page 30)

On my own behalf, I'd also like to present to you the digital home of ELEMENTS on the Internet. Just click on: elements.evonik.de. Whether you prefer the digital or the paper version, I wish you pleasant and instructive reading, and I look forward to receiving your suggestions and comments at: elements@evonik.com

Matthias Ruch
Editor in Chief

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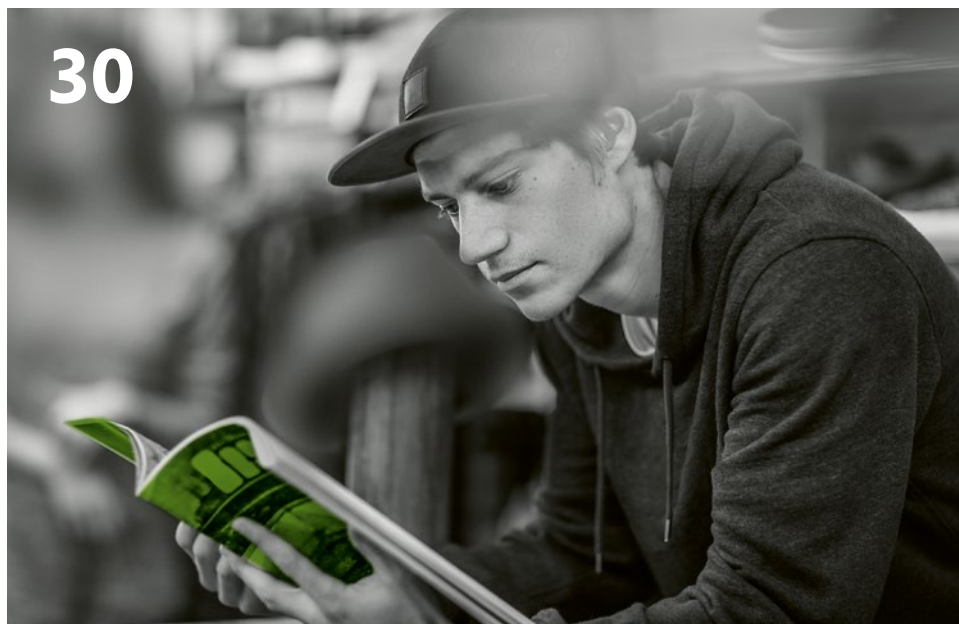
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Coating additives from Evonik put the gloss in high-quality magazines



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Fabiana Scapolo
looks into the future
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LITTLE HELPERS

Bacteria aren't always harmful. In fact, they can even support the healing process of wounds. The JeNaCell startup, which is supported by Evonik, uses *Gluconacetobacter* bacteria, which are seen here under a microscope, to produce nanocellulose. This tear-resistant material is used to smooth wrinkles and also in bandages and wound dressings. It prevents the bandage or dressing from sticking to the wound and enables its painless removal.





A LOOK AROUND THE WORLD

Innovations from science and research

Lobsters to the Rescue

Students in London are developing a plastic from crustacean shells

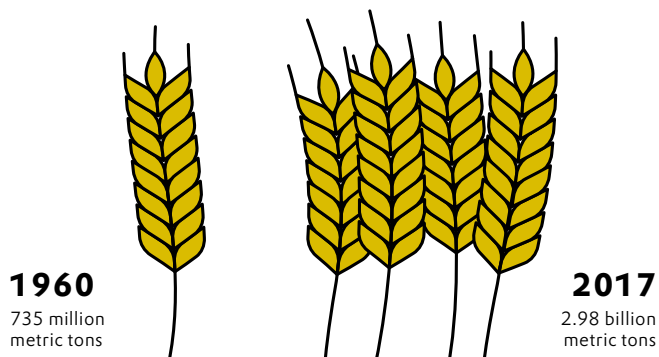
It's been estimated that between 1.2 and 2.4 million tons of plastic waste end up in the ocean every year. But in the future an ocean denizen could become an alternative source of raw material for plastics. At a startup called "The Shellworks," four design students in London have developed a process for extracting chitin from finely ground lobster shells and processing it into chitosan. Adding



vinegar produces a plastic that is more biodegradable than conventional materials. The startup gets the lobster shells from a British lobster restaurant chain. According to the startup's founders, 125 tons of chitin can be extracted from the 375 tons of waste lobster shells that are generated annually. That's enough for 7.5 million plastic bags.

THAT'S BETTER

A Bumper Crop



The total worldwide grain harvest has more than quadrupled in the past six decades. This is primarily due to the development of efficient planting methods and the use of modern fertilizers. That has enabled the step-by-step increase of agricultural productivity in order to feed the hunger of a growing global population—and increasingly to fill the need for energy. In Germany, only one fifth of the grain harvest goes directly into food for humans. Most of it is processed to make animal feed.

Source: The World Bank

710

industrial robots per 10,000 employees were used in South Korea in 2017. That makes South Korea the world leader, followed by Singapore with 658 robots. Germany and Japan take third and fourth place respectively, with less than half of that number.

SMART SENSORS...

...spare the nerves of drivers in Barcelona and also save time. The sensors, which are embedded in the asphalt, guide drivers to empty parking spaces. Even garbage bins and lawn sprinklers are part of this network. Barcelona has had a "Smart City Agenda" for a number of years. What makes it special is the fact that the collected data converge in open-source platforms that are owned by the city rather than a private company. Barcelona's residents can directly access the information via apps.

Liquid Power

An inorganic electrolyte prolongs the life of batteries

Conventional lithium-ion batteries are extremely flammable. That's mainly because of their electrolyte—an organic liquid that transports the electric charge from the negatively charged cathode to the positively charged anode. Innolith, a startup based in Basel, has developed a battery with an inorganic electrolyte made from sulfur dioxide, lithium chloride, and aluminum chloride—a combination that is non-flammable. Incidentally, while the re-

searchers were focusing on increasing the safety of this type of energy storage, they found out that batteries with an inorganic electrolyte have a significantly longer service life than previous models. In the first phase of their rollout, these innovative batteries are to be used in electricity grids. The plans call for large-scale production to begin next year. From that point on, these rechargeable batteries could also be installed in electric vehicles to make them safer to operate.

PEOPLE & VISION



“Our Discovery Could Change the Way Products Are Designed in the Future”

THE MAN

The development of innovative 3D printing processes is advancing rapidly—thanks to scientists like **Hayden Taylor** (38). Even while he was growing up in Bristol in the UK, Taylor aspired to do scientific research. After studying at Cambridge University, he moved to the USA and earned a doctorate in electrical engineering and computer science at Massachusetts Institute of Technology (MIT). In 2014 he became an Assistant Professor at the renowned University of California. Since then, he and his team have been successfully experimenting with 3D printing processes.

THE VISION

The research team headed by Hayden Taylor has developed a new **production method** in which **objects are printed all at once** instead of layer by layer, as was done in the past. The core element of Computed Axial Lithography (CAL) is a projector that irradiates a light-sensitive material such as resin. The material is shaped and then hardens. Through this method, even great works of art can be created in a short time. One of the first objects printed by the research group was a 3D miniature of Auguste Rodin's “The Thinker.”

GOOD QUESTION

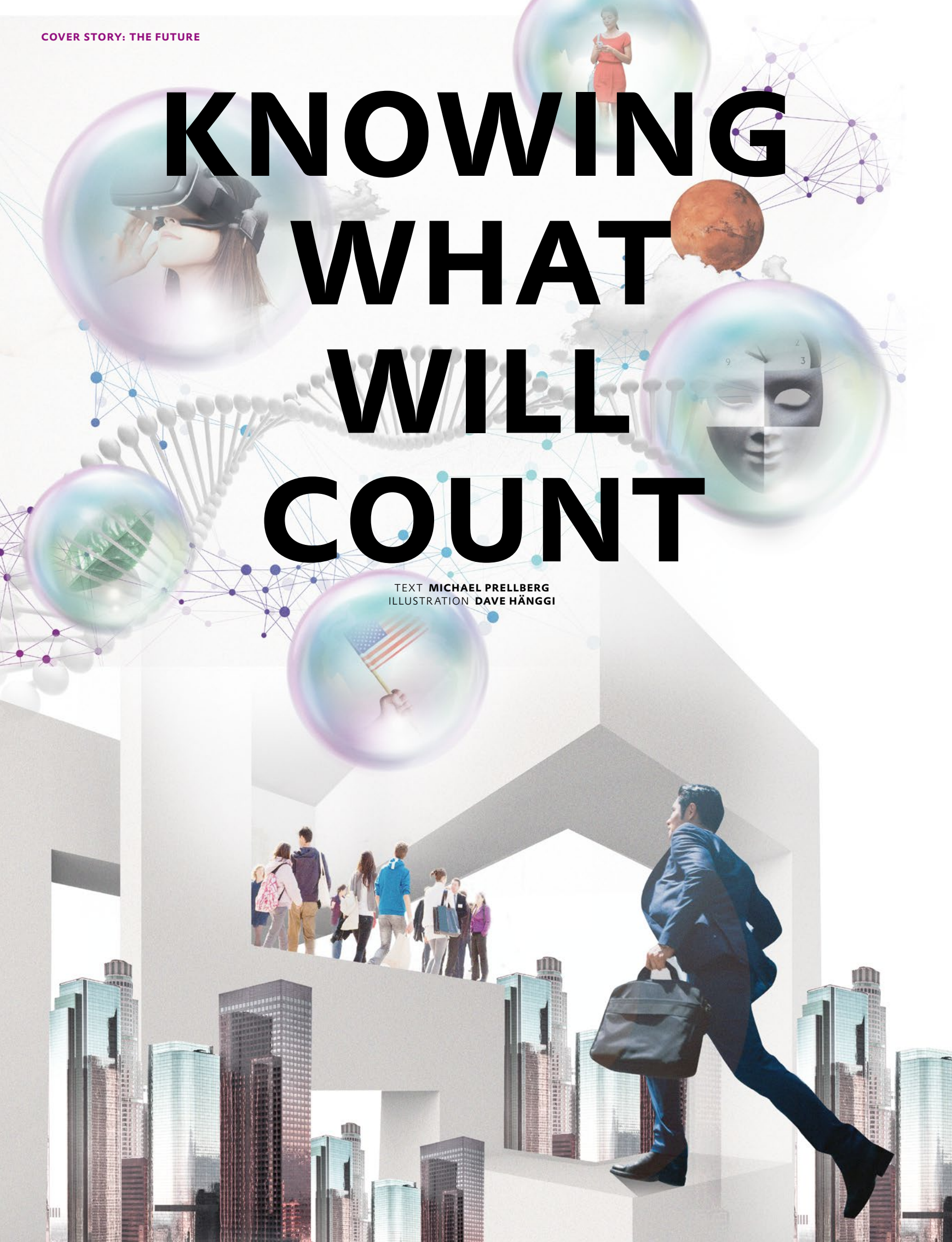


“Professor Dittmeyer, Can Air Conditioners Be Used to Slow Down Climate Change?”

Yes, but only if we develop them into climate-saving devices. Air conditioners and ventilation systems move large volumes of air, which also include carbon dioxide. We need this CO₂ in order to produce chemical fuels that can be used as renewable energy carriers. Air conditioners should be retrofitted in such a way that they can convert the CO₂ in the air into hydrocarbons. Large installations located in supermarkets, for example, could generate significant amounts of fuel—with positive effects on the climate. However, it's clear that this method alone can't even come close to satisfying our need for fuel. Besides, this conversion process requires large amounts of electricity. The electricity would have to be generated without any CO₂ emissions so that this air-conditioning system could really help to save the climate. *Prof. Roland Dittmeyer is the head of the Institute for Micro Process Engineering at the Karlsruhe Institute of Technology (KIT)*

KNOWING WHAT WILL COUNT

TEXT **MICHAEL PRELLBERG**
ILLUSTRATION **DAVE HÄNGGI**



There's more than one possible future. Foresight specialists are developing several "futures" for which companies should be preparing themselves. Evonik is preparing itself for the year 2040 with the help of the five scenarios that are pictured here and described on the following pages

No one knows what the world of tomorrow will look like. Which trends will prevail, and which products will be in demand? Futurologists are using scenarios to help companies prepare for a variety of hypothetical developments and develop appropriate strategies in advance

If cars are equipped with electric motors rather than combustion engines, it's not only the drive system that will be changed. The infrastructure will also be completely reshuffled, and that gives rise to a number of questions: Where will we charge these vehicles, and how long will the process take? Will there be enough charging stations so that we won't run out of power during a drive? Have we got enough raw materials for the e-batteries? Will power grids break down if all the drivers charge their cars at the same time? And if the development of fuel cell technology makes decisive progress, what happens next?

The honest answer is: We don't know. We can't know. But we can simulate the entire process with the help of "What if..." scenarios—representations of possible developments. Even though these scenarios may never take place 100 percent as described, they are very valuable for companies, because they make it possible to prepare for what could happen. The world is becoming more fast-paced and complex, and companies are adapting to these changes. The future is resistant to linear "stay the course" thinking of every kind. We expect the future to include sudden breaks, which are now usually referred to as "disruptions."

THINKING THE UNTHINKABLE

Many companies have their own corporate foresight departments to deal with such future-oriented issues. "Corporate foresight departments are valuable because they enable companies to prepare for future develop-

ments so that they won't be caught off guard," says Cornelia Daheim, the owner of Future Impacts, a consulting firm specializing in this area. But sometimes companies find it difficult to look ahead. As a consultant for foresight projects, Daheim believes her main task is "to question basic assumptions and think the unthinkable"—in different variants called "scenarios." That's a real challenge, she says: "Companies must gain the confidence to accept that what's self-evident today may not be self-evident tomorrow."

But this courage will be rewarded, because it widens our horizons and opens our eyes to previously unimagined risks and opportunities. Björn Theis, a Foresight Manager at Evonik, explains this by using mobility as an example. What would happen if autonomously driving vehicles were available in the future? This technology would enable businesses to make goods transportation more efficient. It could also reinforce the trend toward the shared use of private cars. Owners of autonomously driving electric cars could conveniently rent their vehicles to others via an app during periods when they didn't need to drive.

In this scenario, the vehicles' daily mileage and the wear and tear on their individual components would increase significantly. What's more, the increased number of different users would give rise to a greater interest in antibacterial and hygienic materials for car interiors—that's how Theis continues to develop this scenario. The materials that would be used in the robo-taxis of the future would have to meet new requirements. For the Evonik Group as a specialty chemicals company that supplies products to the automotive supply industry, this kind of change in people's mobility-related behavior means changes in the market, which it will have to identify.

FROM A WEAK SIGNAL TO A TREND

A futurologist's job is complex and multi-layered. Above all, it requires an ability to think in holistic terms. Theis studied ethnology before deciding to focus on researching the future. He joined Evonik in 2014 after working for a consulting firm in the area of corporate foresight and helping to set up the Futures Studies master's degree program at the Freie Universität Berlin.

Evonik's Corporate Foresight department combines social, technological, economic, ecological, and political trends and their possible effects into holistic future scenarios and uses these scenarios to identify opportunities and challenges for the Group. Digitalization is one of the themes it investigates. "This is an important trend that can't be overlooked, and it will therefore →

“We have to break the large whole into smaller pieces”

BJÖRN THEIS, FORESIGHT MANAGER AT EVONIK



have a strong impact on the future of the specialty chemicals sector,” says Theis. But what does this mean for Evonik in concrete terms? To find out, Foresight team members talk to experts who are investigating the various facets of the digital transformation. What will be the impact of artificial intelligence in the future? What kind of work will it do? And where will it be used? What roles will robotics, cryptocurrencies, and virtual reality play in the chemical industry? There’s no end of the questions for which Theis and his team are seeking possible answers.

The creation of plausible and consistent scenarios is a lengthy and laborious process. Countless factors have to be analyzed and connected with one another. And the foresight experts don’t base this work on gut feelings or rough estimates. Futurologists have spent decades developing methods for identifying and analyzing trends. “Trends can be documented empirically and reliably. I know how these things develop,” says

Andreas Neef, a Managing Partner of the Z_Punkt consulting firm, where Björn Theis used to work. Some sequences of phenomena are regarded as mere “weak signals.” “These are isolated events that only permit us to make assumptions,” Neef explains. Only if several weak signals come together do they slowly develop into a trend.

But even if the researchers have identified such a trend, in many cases it’s not clear what it will lead to. “The basic danger is always that we may overestimate or underestimate certain developments,” says Neef. He uses the “Fridays for Future” school strikes as an example. Is this a flash in the pan, or will the demonstrations grow into a global movement? There are still many “critical uncertainties” interacting with one another.

One of the approaches used by futurologists to represent these interactions is the “explorative scenario method.” They create concrete and consistent representations of how the world could look in the future. “A scenario tries to align the many different developments with one another and also to include their interactions,” says Neef. “Because this attempt can never be completely successful, we always look at several scenarios that assign more or less weight to certain aspects whose occurrence we consider more or less probable.” The companies don’t simply select their favorites from the scenarios that are offered to them. “Instead, they use all of the scenarios to derive a strategy that is as robust as possible.” In this context, “robust” means that the company can make preparations for the future no matter which scenario prevails.

THE MAJOR GLOBAL FORCES

Foresight Manager Theis and his colleagues also use this method to help Evonik initiate innovations purposefully and at an early stage and to review and further develop long-term strategies. The Foresight team has developed five scenarios for the period between now and 2040. In the “Digital Champions” scenario (page 19), the major Internet companies use their know-how and their mindset to tap an increasing share of the added value of traditional industries. The “Sustainability Paradigm” scenario (page 15) describes how sustainability becomes the defining principle of economics. In the “Chinese Dream” scenario (page 18), China develops into a technological, economic, and political global force. In the “Turbulent Times” scenario (page 14), nationalism, fake news, and populist forces lead to ongoing deglobalization. The “Deceptive Calm” scenario (page 13) looks at the future from another perspective. In a system based on “business as usual,” problems accumulate and possibly lead to collapse.

These are five alternative courses of development that could become relevant to Evonik’s business →



FIVE “FUTURES” FOR THE SPECIALTY CHEMICALS SECTOR

The foresight experts have developed five different scenarios for the year 2040, all of which seem plausible. The challenge is now to develop a corporate strategy that will make the Group well-prepared for all of these possible developments.



DECEPTIVE CALM

The world has changed since 2020—but only slowly and in small steps. There have been no drastic shifts in geopolitics, technology or social conditions. That has meant stability, robust economic growth, and business as usual. At the same time, the search for solutions to the major global problems has been repeatedly postponed, and as a result the negative consequences have become even more dire. Initially, everything stayed the same. China did not manage to replace the USA as the dominant superpower. Global trade flourished, and the elimination of trade barriers led to a further increase of global value chains. This enabled numerous developing nations to attain relative prosperity during the past 20 years. The global middle class

has increased by three billion people since 2020. Environmentally friendly concepts of consumption and mobility are playing a negligible role. The careless use of resources, the close collaboration of the oil-exporting states, and the lack of political will to shift to renewable energy sources has ultimately led to an increase in environmental damage, and the climate goals have been missed by a large margin. The Earth has been exploited far beyond its limits. The younger generation in particular no longer wants to bear the resulting social and economic costs—and is staging worldwide protests calling for a radical change of course and strict regulations. The established companies, including those in specialty chemicals, are in a comfort-

able situation at the moment because of the growing demand for their products. The traditional business models are mostly intact. Profits are surging, and many new jobs are being created. Innovations such as 3D printing, light field displays, and service robots have become standard in many areas. However, the search for completely new technical solutions and materials and more environmentally friendly processes is secondary to aspects such as high quality at affordable prices, as well as quick and reliable delivery. Nonetheless, as the consequences of climate change become more drastic, people and legislators are demanding with increasing urgency that companies reverse the trends that are destroying the environment.

TURBULENT TIMES

The world of 2040 is deglobalized. Populist and authoritarian governments have pushed back democracy, press freedom, and an independent judiciary all over the world. The USA has lost its role as the global policeman, and no other superpower has replaced it. Nations are increasingly striving to promote their own interests, and the international community has been weakened. Instead of a free world order, there is a conflict-laden multipolar order in which global challenges such as climate change are being inadequately addressed.

The internal conditions of many countries reflect this picture: Societies are strongly polarized in their thinking, and they offer clashing ideologies concerning the right path to the future. Nongovernmental organizations exert massive influence on political decisions. Rational discussions are often hardly possible, because “fake news” are becoming more and more widespread. Technical progress is increasingly regarded as a threat: People are resisting the negative effects of automation and connectivity, such as mass unemployment and the increase of cyber-crime. There are no effective solutions for the consequences of digital technologies, robotics, and artificial intelligence. In a world full of tensions, cyberwars are occurring with increasing frequency.

This context poses huge challenges to business. The nationalism that is raging throughout the world is leading to trade wars and an increase of protectionism. Significant trade agreements have expired and been replaced by bilateral contracts, and the exchange of goods and capital is strongly regulated. Champion nations are emerging in the areas of industry and business. Companies are making all of their activities more local, ranging from research and development to production and sales. They are also trying to create even closer relationships with customers and raw material suppliers. It’s becoming harder for companies to engage in a dialogue with all social groups, even though this dialogue is essential.



“Companies must gain the confidence to accept that what’s self-evident today may not be self-evident tomorrow”

CORNELIA DAHEIM, OWNER OF THE FUTURE IMPACTS CONSULTING FIRM



operations in the medium to long term. In this context, Theis talks about “futures.” “We’re not making any forecasts, because there’s more than one possible future,” he says. The five scenarios worked out by Evonik’s researchers provide the company with a range of future options. Each variant is based on plausible and very well-founded assumptions and is logically deduced in four steps (see the graphic on the right).

The scenario project began with a question: What major forces will have an impact on specialty chemicals companies over the long term? “We’re looking at the major forces in the world,” says Theis. To this end, the team spent the past months interviewing over 100 in-house and external experts from the fields of science, politics, and business, assessing future studies, and conducting workshops. Their work resulted in a list of more than 100 factors that will have a profound impact on the specialty chemicals sector. They are subdivided under the headings Ecology, Politics, Society, Technology, and Economics.

In the second step, the experts reduced the multitude of influencing factors by selecting the key factors from the list according to certain specific criteria. These factors will have a substantial impact on the specialty chemicals sector. However, in many cases their future development is extremely uncertain, and they are also interacting with many other factors. The 25 factors that will have the strongest impact and form the basic framework of the scenarios were comprehensively ana-

lyzed and described. They include factors such as population growth, artificial intelligence, and climate change.

“In the third step, we asked how these key factors could plausibly develop in the future,” Theis explains. Between two and four future projections were derived for each key factor. In some cases, conflicting developments are possible. For example, it’s conceivable that biotechnology, including genetic engineering and artificial organisms, will receive worldwide acceptance—but it could also be banned.

Finally, in the fourth step the projections were connected with one another and assigned different weights. Within a network of stable and plausible relationships between the projections, the five computer-supported scenarios were created.

FORESIGHT LEADS TO SUCCESS

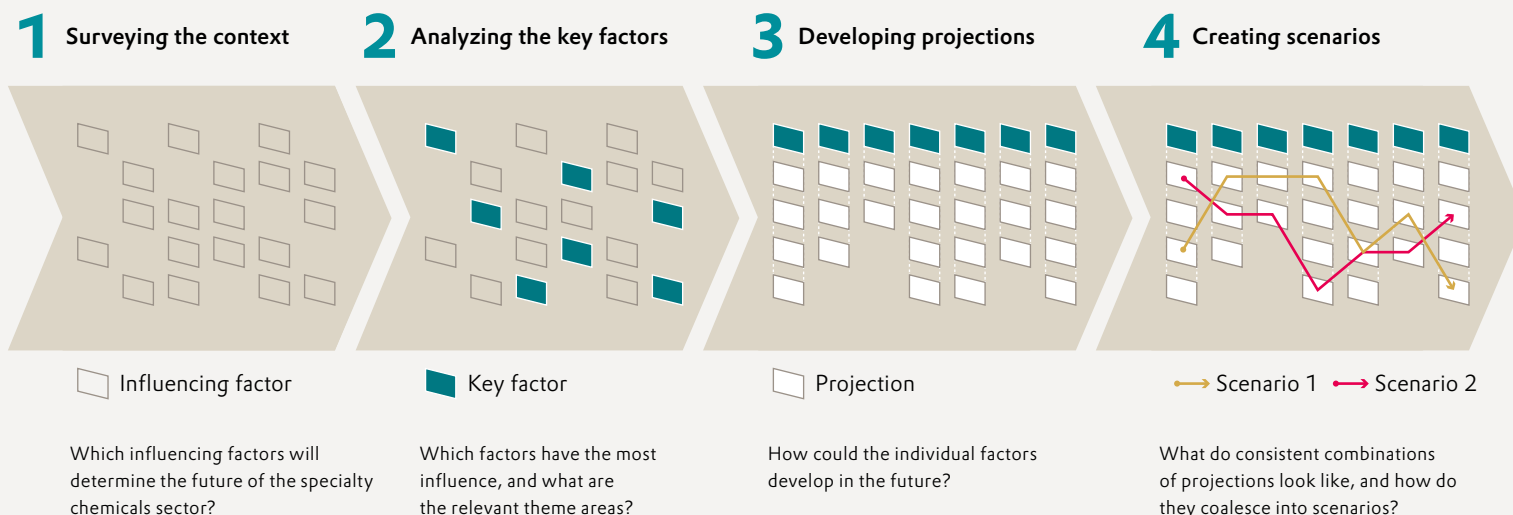
The scenario method was developed in the 1950s in several places including the RAND Corporation, a US think tank that was founded after World War II in order to advise the USA’s armed forces. Later on, companies including Motorola, General Electric, and UPS also assigned researchers the task of making it easier to calculate the future.

In the 1970s, corporate foresight created a genuine competitive advantage for the Shell Oil Company. The company’s managers had run several scenarios that played out what could happen if the supply of petroleum decreased. When OPEC imposed an embargo on oil deliveries to various industrialized nations in 1973, Shell was prepared and could react promptly. By the end of the oil crisis, Shell had become the world’s second-biggest and most profitable company in its sector. Back then, this success spurred other companies to also try their luck with the scenario method. However, many of these attempts were discontinued. It was evidently difficult to find the right path between methodological overengineering and superficiality.

Since that time, however, the methods have been considerably refined. René Rohrbeck, a corporate foresight expert who is a professor at Aarhus University in Denmark, deplors the fact that even today many companies are addressing the challenges of the future too hesitantly. “Even extremely convincing scenarios fail to reach their target if they are not channeled into strategic action,” he says.

Rohrbeck believes there are three main reasons why even well-meaning managers are not drawing the necessary conclusions. Many companies are overstretched by the rapid speed of change in markets and customer wishes. Because of the stringent demands of their daily work, managers don’t take the time to discuss future scenarios. In addition, companies often behave like su-

HOW EVONIK DEVELOPS FUTURE SCENARIOS



pertankers: It takes them a long time to change course, especially if the change means calling currently profitable business areas into question without any guarantee of success.

ROBUST STRATEGIES FOR TOMORROW

At Evonik, decision-makers at all levels and in all the business areas of the Group were involved early on in the development of future scenarios. Chief Innovation Officer Dr. Ulrich Küsthardt is confident that the scenarios for Evonik's long-term planning will create great added value. After all, they provide a basis for strategies that respond to the largest possible number of eventualities. "The ideal outcome would be a no-regrets decision that guarantees that you won't do anything wrong," says Küsthardt. However, even the very best scenarios won't help the company make such a decision. "We don't know the future; we only have well-founded ideas about what could happen," says Küsthardt. "However, our goal is to develop optimally robust strategies for the innovation of tomorrow and beyond."

On the way to this goal, the scenarios of the responsible strategy and innovation units are extensively discussed at Evonik. "We're like chess players in this regard," says Küsthardt. "We look at the various options and play them out." For example, companies that want to be prepared for "Turbulent Times" must ask questions such as: Should we strengthen our regional and local units? If the world becomes less globally integrated, what will our future business relationships with customers, dealers, and suppliers look like? Do long-term contracts still have a future, or will contract terms

become shorter? "It's always a question of weighing up the issues. The discussion of the possibilities in itself already creates added value for the participants. And if concrete measures are then derived from the discussion, we've done a good job," says Theis.

As a foresight manager at Evonik, he long ago stopped needing to persuade people that his approach was useful. "As soon as the managers realize how relevant the scenarios are for their work, they're all fired up," he says. Today the managers can't wait to read the Corporate Foresight reports, says CIO Küsthardt, adding, "The managers have to make decisions and want to initiate activities. But they can only do that if they know what options they have." —



"The basic danger is always that we may overestimate or underestimate certain developments"

ANDREAS NEEF, MANAGING PARTNER
OF THE Z_PUNKT CONSULTING FIRM



CHINESE DREAM

By 2040 China has regained the decisive global role it had already played during long stretches of history. It is setting the international agenda culturally, politically, militarily, and with regard to environmental protection. It has built up its power and influence step by step, first in Asia, then westward along the New Silk Road all the way to Europe, and finally worldwide. China has become a global superpower. Never before has a national economy been so successful. China's targeted industrial policy has efficiently promoted Chinese companies and massively advanced science and new technologies. The Chinese economy has seized its opportunity. Local companies have

used their experiences and success in a growing domestic market, as well as their technological edge, to become serious competitors of Western companies in the global market. "Made in China" has become a mark of quality. China is the leader in almost all the relevant technological fields: artificial intelligence, robotics, biotechnology, e-mobility, and environmental protection. In addition, the Chinese government has recognized and exploited the opportunity offered by digitalization: Three Chinese companies dominate the world's mightiest digitalized economic system. Simultaneously, China has reorganized its economic and social structures. It is deliberately promoting

low-CO₂ lifestyles, environmental protection, green technologies and products, and clean production and energy. China has thus become the world's first eco-civilization.

The established industries of the Western world are facing a strong new competitor; on the other hand, they can profit from a continually growing Chinese market. However, in order to do so they must adapt themselves even more precisely to Chinese customers and cooperate with Chinese companies. That's the only way they can genuinely benefit from their innovative strength. The language and mindset of the new old superpower are also increasingly penetrating Western companies.

DIGITAL CHAMPIONS

The global digital champions have used their know-how and their well-filled “war chests” to gain ground in traditional sectors. Through their know-how they are occupying the interface with these sectors’ customers, thus acquiring considerable portions of the value creation of traditional industries. At the same time, companies are increasingly working together in horizontally networked ecosystems and establishing new digital business models.

This development is going hand in hand with growing individualization: Products and services are being more and more precisely adapted to customers. The concept of “economies of scale” is being replaced by “economies of access.”

Ecosystems are combining their products and services for a certain need (such as mobility or healthcare) so that consumers can receive a whole spectrum of products and services from a single source.

By 2040, the technical precon-

ditions for complex offers of this kind have been fulfilled: A full-coverage broadband network, as well as the use of artificial intelligence and quantum computing, are standard. Smart devices enable machines to communicate with one another and to share information. In daily life the smartphone has been replaced by devices that are controlled by means of the voice, gestures, eye movements or even thoughts. These technologies are even making virtual meetings possible—and thus drastically decreasing traffic volumes.

In this environment, traditional manufacturing companies must find a new role for themselves and try to develop their own ecosystems or to occupy the

control rooms of these systems. The use of new digital technologies is urgently needed—especially in response to increased customer expectations (individualized products and services, fast delivery). Even small companies can access simple and inexpensive digital high-tech solutions, because the digital champions offer quantum computing as well as research and development services. Increasing automation may result in fewer people being employed in the areas of traditional production, whereas there is a strong demand for digital specialists.



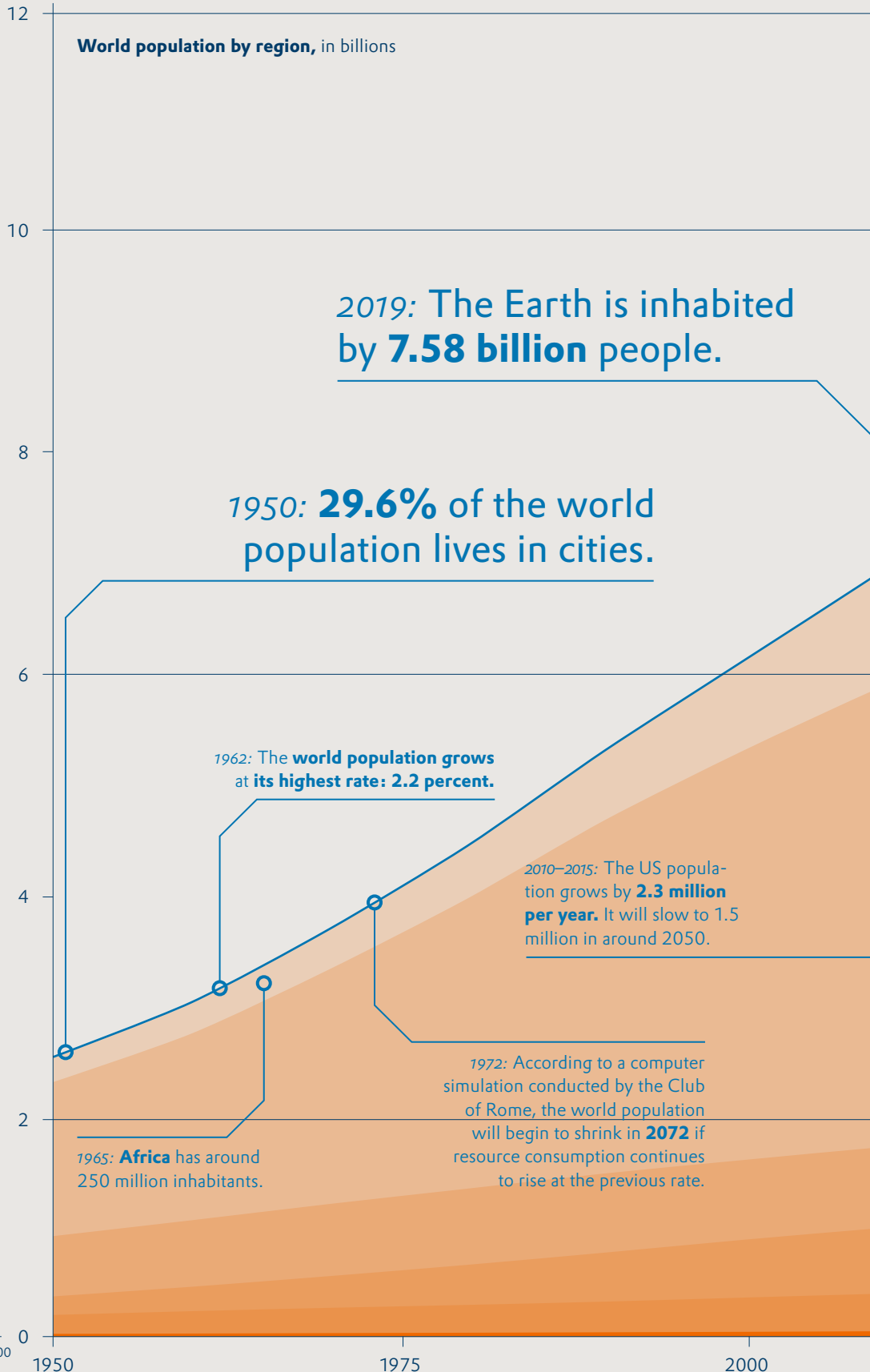
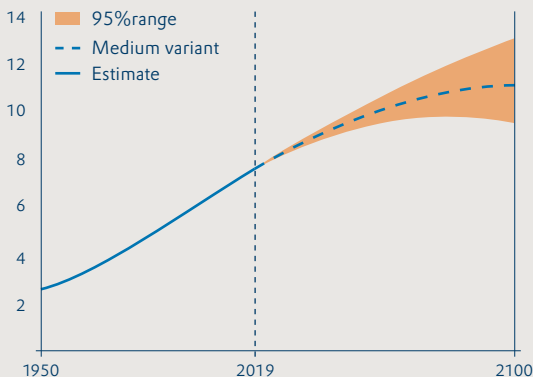
WE'RE MULTIPLYING

Unlike many other phenomena, **demographic developments** can be forecast fairly accurately. It's certain that the world's population will continue to grow, especially in Africa. However, the pace will decline substantially between now and 2100

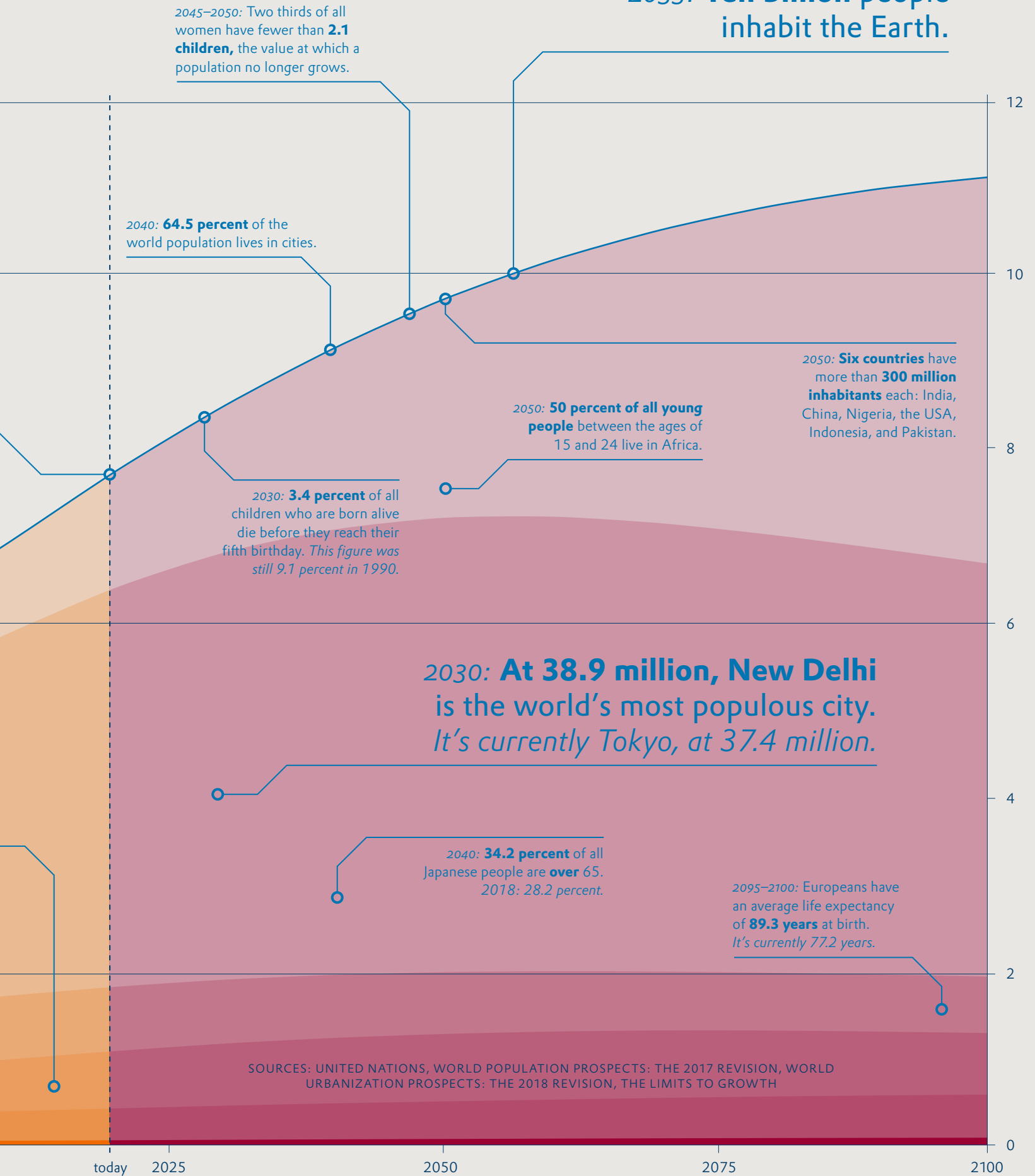
Key:

- Estimates (1950 to the present)
- Forecasts (until 2100)
- Africa
- Asia
- Europe
- South America
- North America
- Oceania

The UN uses different projections for its forecasts. The information in this overview is based on the medium variant. It's **95 percent likely** that the values will be within the marked range



2055: **Ten billion** people inhabit the Earth.



Fabiana Scapolo is the Deputy Head of Foresight, Modelling, Behavioural Insights and Design for Policy at the Joint Research Centre (JRC) of the European Commission in Brussels. This unit is responsible for the EU Policy Lab, in which innovative forms of policy-making are investigated and developed. Scapolo, a native of Italy, studied political science in Milan and received her doctorate in foresight methods from the University of Manchester.



“MODERN TALKING”

INTERVIEW **CHRISTIAN BAULIG AND BJÖRN THEIS**
PHOTOGRAPHY **HENNING ROSS**

“Research,” “Innovation,” “Foresight” – colorful giant letters on the glass facade of this futuristic building indicate its purpose. The Joint Research Centre of the European Commission in Brussels is the home of the EU Policy Lab, where Fabiana Scapolo and her colleagues develop visions of the future of the European Union. For this interview, Scapolo received us in a conference room equipped with flipcharts, pin boards, and high tables on which stand bowls full of Lego figures. “We often use these Lego figures in discussions to represent various interest groups,” she explained. However, during her hour-long conversation with the Evonik reporters, there was no time to use any of the plastic cowboys, nurses or firefighters.

In a few days the European Parliament will have its inaugural plenary session and elect the next Commission President. Do you think Europe is heading towards a positive future?

FABIANA SCAPOLO This is more a question for someone who has a crystal ball. In Foresight we don’t predict the future. There are a number of very important challenges that the EU is facing at the moment. Europe

The EU Policy Lab develops scenarios for the European Union’s future in order to help political leaders make the right decisions. Deputy Head Fabiana Scapolo talks about the risks of growing nationalism in the European Union, the opportunities innovation can provide – and the importance of interacting with citizens

has to get closer to its citizens and to try to reduce the distance people feel towards its institutions. For me, this is the basis for the success of the next European Commission and the next European Parliament.

That sounds understandable. But how can you manage to get closer to citizens?

The Commission doesn’t have the mandate to legislate on all domains. There are certain areas where legislation and the implementation of European law are left to the member states. What has to be done is to communicate the positive stories of European institutions in a more effective way and to reduce distance to citizens. The Commission is taking some initiative in this respect and I think we are moving forward in this direction. →



How are businesses and political institutions preparing for the future? Evonik foresight expert Björn Theis (left) and *Elements* reporter Christian Baulig talk to Fabiana Scapolo

Obviously, we're living in an era of rapid change. How does this affect your work of looking into the far future?

It has certainly become more difficult to develop plausible scenarios for the next 20 years. But if we don't engage and try to understand what the future may unfold we will have even fewer possibilities to contribute to shaping what the future could be and to act on it. We need to push our policymakers to take the longer-term perspective more into account in the development of policies. Otherwise, we will be losing opportunities.

Do policymakers listen to you more carefully today than a few years ago?

Yes. They understand that it is necessary to develop what is called an anticipatory culture. For example, artificial intelligence (AI) might lead to a drastic loss of jobs. If you look at it closely it's true that a number of routine tasks will be taken over by automation but, on

the other hand, we can identify many opportunities that will open up thanks to AI: It could facilitate and speed up processes and boost productivity, thereby contributing to positive growth. It is still an area full of uncertainties. However, looking into the future allows us to explore possibilities and analyze what can be fears and threats but also to identify what can be our opportunities and hopes.

We always thought that politicians tended to be short-sighted, as they think in terms...

...and we are aware of that. During their mandate politicians, indeed, try to focus on solving current problems. However, we have to be conscious that some of the challenges and problems we experience today are megatrends that will continue in the future. If a policy takes into consideration what implications these megatrends have on policy issues today, we will have more sound policies. Politicians are beginning to understand that.

Which challenges in the EU should policymakers focus on in particular?

First of all, the change of our environment and how we deal with all the threats that come along with the rise

“It has become more difficult to develop plausible scenarios for the next 20 years”

Brexit, populism, migration—Scapolo’s team develops strategies for the EU’s response to these challenges



of the CO₂ level, pollution, environmental degradation, and our excessive use of resources. It’s so important because it has very strong economic and social implications. However, here lies a chance for politics if citizens realize that there is awareness and action is being taken on global warming and the maintenance of the environment. And of course there are big economic challenges that are related to globalization and to what Europe’s role is in the worldwide picture.

Do you think that looking back from 2040 Brexit will be seen as a “game changer” in the history of the European Union?

It isn’t yet clear how Brexit is going to evolve within the next two years. It doesn’t matter if there is a deal

or not—this won’t be the end of the story, it will just be the beginning. Over the last couple of years we’ve been experiencing a rise in nationalism and populism. Potentially, there may be a lot of political instability and we don’t really know how it will evolve. This is something we should be looking at carefully in our foresight activities.

Within the EU, regions like Catalonia are striving for independence. What will be the consequences for the European Union if they succeed?

If this type of scenario materialized, Europe would have to adapt and give more power to the regions. This doesn’t necessarily have to be seen as a negative trend. Recently, we finalized a study about the future →



“We should really fight against fake news and misinformation”

As a scientist, Fabiana Scapolo marshals well-founded facts against unsupported promises and nightmare scenarios

of government that touches upon this issue: In one of the scenarios that is called “super-collaborative government” we foresee a new institution at the European level that is called “European Convention of Mayors.” After all, it’s at the local level where you can interact most closely with the citizens and where you can co-design policy measures that take into consideration people’s needs. It’s possible that we will see a political shift towards regional types of institutions, but we have to ensure that we keep a level of governance that helps to bring regions together and tackle transregional and transnational issues.

According to recent opinion polls, migration is the topic of most concern for many Europeans. What should be the political answer to the steady inflow of people?

Probably this migration flow is not going to diminish. This, of course, has consequences for how the EU will look in 20 years. The question is: How do we ensure that enough effort is put into integration? These people help us in terms of demography, as the European population is getting older. Some immigrants are skilled people that could fill gaps in our economy. On the other hand, we also have to be attentive to the preservation of European cultural values. It is a matter of finding the right balance.



i The EU Policy Lab

The Joint Research Centre of the European Commission, which is located on the outskirts of the European Quarter in Brussels, has been the home of the EU Policy Lab since 2016. Here 24 scientists develop methods and processes for making European policy-making more effective and more successful. They cooperate with a number of policy labs in the member states of the EU. In addition to developing scenarios, the experts use approaches from the fields of behavioral science, simulation, and design thinking. Their goal is to promote more intensive interaction between political decision-makers and citizens.

Many young people are particularly afraid of climate change. Will their “Fridays for Future” strikes evolve into a megatrend?

We don’t know yet. But this movement is positive. In a way the young generation is ringing a bell, they are telling us: “Hey, this is something we ask you to take care of because it’s about our future!” With our “horizon scanning” we try to detect such phenomena that are not yet on the policy radar but that can become very important issues in the future. And it’s our duty to bring this to the attention of our leaders.

As a scientist you work with facts. What happens if more and more people get into politics who don’t really care about facts and make up their own truth?

Our mandate is to bring evidence into policymaking. This is why we should really fight against fake news and misinformation. I’m optimistic that we will succeed. Just look at the big social media corporations that have started to take steps in acting against fake news. In Italy, for example, Facebook recently closed down accounts that were related to spreading fake news.

How can countries improve their fitness for the future? Do you see any role models in Europe?

Estonia is good example in the field of digitalization. But there are also projects on societal innovation in France, Sweden, and Spain. In a couple of countries policy labs have been established with the objective to co-design and co-develop policy together with citizens. This could be a good direction to go. By the way, digitalization is offering an opportunity to listen more carefully to people’s concerns.

Still, Europe is in danger of losing its role as a global innovation power and falling behind countries like the United States or China. Are we Europeans too risk-averse toward innovation?

I don’t think so. Maybe we are more cautious compared to other regions of the world. But having discussions about long-term implications can be positive even if in the short term you may lose competitiveness. What’s more important: We should focus on our education system. We should learn from other countries and give young people opportunities in order to retain the knowledge that we develop. There are a lot of people who study in Europe and then they go either to China or the US—those are missed opportunities.

What are your personal plans for the year 2040?

(laughing) I would like to live in the south of Europe, as I need sun. I hope that in 20 years’ time I still can be active at the community level—together with young people. —



Christian Kullmann is the Chairman of the Executive Board of Evonik

We Can Provide Answers Only If We Act Together: As Europeans

The EU is a project committed to peace and prosperity in a globalized world. To keep this project alive, we must learn to talk about Europe more positively and shape the mechanisms of political decision-making more effectively

by Christian Kullmann

There's only one possible response to the results of the European election: The EU must become even bolder and more enterprising internally in order to stay strong externally. That's the only way this unique economic and peace project can be permanently protected from threats—including those coming from its populist opponents within.

One important aspect of the European election should be emphasized first of all: The high level of voter participation in Germany and in many other countries demonstrates that European democracy is working. People take Europe and European politics seriously and consider them important. The fact that nationalistic and anti-Europe forces will also be represented in considerable numbers in the European Parliament is certainly a serious challenge for European democracy. However, it does not change the fact that the pro-Europe parties dominate in the European Parliament. Democracy is very much alive.

And it has challenges to meet. That's because Europe is facing tremendous changes. The political and economic developments in America and Asia are having a direct impact on us. We need answers to the questions that these changes are bringing with them. And we can provide these answers only if we act together as Europeans. No country, including Germany, can do that alone.

At stake are our values, our interests, and our future role in the world. Our challenge is to balance varying goals in order to cooperatively achieve a good outcome. That's what we need to do inside Germany and within Europe as a whole.

For more than five decades, the European integration project has not been called into question. It has not been loved everywhere, but it has at least been tolerated. As long as the economic situation was favorable, business and a shared currency fulfilled their purpose as a binding element. But then the financial crisis that began in 2008 thrust Europe, and especially the euro, into a deep crisis. The dispute over European debt drove a deep wedge between the EU members, and the rigorous course toward stability led to harsh social upheavals in some countries. Many of the anti-Europe parties that have now been voted into the European Parliament owe their ascendancy to these political developments.

The wave of migration and Germany's decision to open its boundaries have also led, both here and abroad, to a loss of trust in shared European solutions. We could and should have regarded these crises as an opportunity to work even more intensely on European integration and to learn from our mistakes. Instead, many member states have

“Germany on its own is simply too small to be able to play a serious role in the future global concert of the major powers”

succumbed to nationalistic rhetoric that more and more often advocates rejecting joint action and promotes mistrust of the EU. Brexit is yet another momentous destructive element.

TRUST AND FRIENDSHIP INSTEAD OF MISTRUST AND HATE

Of course this mistrust is not a new phenomenon. It could even be regarded as an opportunity to move forward. That's because suspicion of one another was also prevalent at the time when this community of states was first established. When the Treaty of Rome was signed in 1957, there was little trust between the former warring nations. The determination to form a community was not based on affection or mutual understanding. It grew out of the painful realization that exclusively nationalistic actions lead to catastrophe—and it also grew out of the far-sighted political action of a number of committed Europeans. There was serious concern that without this union people in one country would once again shout, “We come first!” No European country should ever again try to oppress another one through its military or economic might.

Only through the creation of the European Union and through the positive experience of sharing and acting together have deep trust and friendship arisen over the years to replace the mutual mistrust that had previously existed for centuries. The European Union developed into a region of freedom, democracy, equality, and the rule of law. The fact that the memory of this unique development has faded after less than 70 years, and that the EU no longer exerts a fascination beyond national boundaries as the greatest peace project of all time, is a cause for concern.

In addition to the EU's function of safeguarding peace and freedom, an equally significant aspect is the fact that our current prosperity is based on its success. In the period since the foundation of the European Union, the prosperity of its member states

has tripled. The establishment of the European single market more than 25 years ago has increased the gross domestic product by one third in Germany alone. In terms of economic well-being, the EU states have moved into an outstanding position among all the industrialized nations worldwide. This prosperity is based not least on the success of globally operating companies such as Evonik. The single market is massively expanding our sales opportunities. It's not a coincidence that the EU is responsible for the highest percentage of worldwide exports of industrial products. A duty-free international market with an annual volume of more than €14 trillion is open to us. The single market results in intense Europe-wide competition that has a positive effect on our prosperity and drives us to outstanding performance on a global scale.

Moreover, international competition is taking place not only between the EU's individual member states but also, and much more intensely, between Europe and other regions of the world. Meanwhile, the economic power blocs have been shifting very significantly for years now. China has caught up dramatically in terms of its economic output, and today it stands almost at eye level with the USA and the EU. This rise will continue. In the foreseeable future, China will have not merely caught up with the current growth rates of the EU and the USA but overtaken them. We need to work hard to maintain our standing in the global market. But we will succeed in this enterprise only as the EU, not as independently operating industrialized nations. Germany on its own is simply too small to be able to play a serious political and economic role in the future global concert of the major powers.

A look at demographic developments demonstrates this very clearly. According to forecasts by the United Nations, the global population will increase by almost one third between now and 2050. Today Germany's share of this total is barely one percent, and it will continue to decrease in the period un-

til 2050. Only if we work together with our European partners will we be able to maintain a certain level of geopolitical relevance.

The basic requirement for a well-functioning and prospering European Union is the active approval of its population. An EU that is perceived solely as a cumbersome administrative apparatus in Brussels does not have a positive long-term outlook, because it is not helping to create a European identity. How can we once again strengthen people's faith in the project that is the European Union?

For one thing, we have to learn how to talk about Europe more positively. The common practice within the member states of declaring political successes as their own and ascribing failures to the EU is counter-productive. Those who publicly discredit and disparage the European project are playing right into the hands of the populists on the left and the right. This is a challenge not only for the politicians but also for the media, social institutions, and businesses.

For another thing, the EU's political decision-making mechanisms must become more effective. In the White Paper on the future of Europe, the outgoing President of the European Commission, Jean-Claude Juncker, has taken a path that includes expressing self-criticism regarding the current mechanisms. Concentrating on selected areas of policy even more than before in order to reach quicker results is the right approach. In order to increase efficiency, the principle of majority rule should be applied to decisions made by the member states, rather than requiring all too often that the important decisions made by the Council must be unanimous.

Only if the EU is a powerful unity that is capable of reform will it be able to hold its ground in the outside world in the future. And only then will it be able to develop the charisma that will inspire its citizens' continued or renewed enthusiasm about this project, on which our future well-being crucially depends. —



Thanks to additives, heat and UV radiation have as little effect on **automotive coatings** as cold and rain. Even small stones thrown up from the road surface don't leave any damage

COOL COLORS

At home, in the car, and while shopping, voice-controlled digital assistants have become a part of daily life. In the future, they will also make lab work easier. The first such assistant to specifically help scientists in the coatings industry is named COATINO™

TEXT NADINE NÖSLER

Bearing names such as Siri and Alexa, virtual assistants are now a part of the family in one out of five American homes. Boasting endless patience, they accept any voice command they are given and, if everything works right, will then play the desired music, provide a weather forecast or update the user's calendar. Voice-controlled digital assistants promise to provide us help in our daily lives. They are rapidly spreading. Whereas they were found in only one percent of US households in 2016, this figure had risen to 20 percent just two years later. They are also used in no less than 13 percent of German households.

If everything goes according to Dr. Gaetano Blanda's wishes, this will only be the beginning. Blanda wants to turn voice-controlled digital assistants from simple

helpers for daily life into chemistry experts and use them in a place where a comprehensive amount of specialized knowledge is needed and a technical language is spoken: the laboratory.

As the Head of the Coating Additives Business Line at Evonik, Dr. Blanda knows about the great demands that the new lab assistants have to fulfill with regard to scientific expertise and language skills. His team specializes in formulations for the coatings industry and the associated additives. In order to exactly meet the customers' wishes with respect to color, gloss, and durability, the experts have to create complex mixtures in the lab which they supplement with the right additives. Thousands of combinations are possible—far more, in fact, than the human brain can handle.

The experts spend correspondingly much time searching through notes and data sheets on their desks. So a digital assistant will now help users research and adjust ingredients directly in the laboratory. The assistant's name is COATINO™. →

The idea for COATINO™ was born during a strategy meeting at Coating Additives. “We talked about new ways in which business could develop,” says Dr. Oliver Kröhl, Head of the Strategic Business Area Development at Coating Additives and the project’s manager. “Innovations are no longer just limited to finished products or processes. Instead, you need to demonstrate your ability to come up with solutions in the form of new services and business models.” The researchers focused on everyday challenges for the formulation of coatings and paints and soon decided that they could use a voice-controlled digital formulation assistant. The team was thrilled by the idea. But is this what the experts in the lab actually need?

FROM CAN TO PROTOTYPE

To find this out, the scientists decided to simply start working. They coated an empty can of paint in the

company’s colors. They then put it into the laboratory, where they filmed a discussion between a colleague and the can. In the video, the user asked the can about a suitable waterborne anti-foaming agent for a wood coating. The can gave its reply, provided the lab employee with a selection of products, and ordered a sample. “Back then, the questions were answered by a colleague who stood behind a wall,” says Kröhl. “Although this was rather ad hoc, we wanted to tangibly test our idea with customers and quickly get feedback.” The video was shared with a number of customers and the team also conducted structured interviews. The idea engendered a great amount of interest.

This approval encouraged the developers to move into uncharted territory. “We’re experts for paints and coatings, but not for voice-controlled assistants,” says Kröhl. “That’s why we knew that the project might not work. However, we and our customers thought it had such great potential that we were willing to take the risk.” Their aim was to develop a prototype assistant in time for the European Coating Show, the world’s most important trade fair for the paint and coatings industry.

This was no easy task, because conventional voice-recognition systems were unable to handle the specialist vocabulary. “The usual assistants simply can’t understand our language,” says Kröhl. They quickly reach their limits when you ask them about dispersion, rheology or silicone resins, for example, and they can, at best, only supply general information.

Additives in **lipstick** ensure high color stability and prevent clumping of the ingredients



i A test course for coatings

The high-throughput experimentation unit for the testing of coating recipes at the Coating Additives Business Line provides an important pool of data for the coating industry’s digital assistant. This unit, which is housed at Evonik’s Goldschmidtstraße location in Essen, doses raw materials, formulates them to create coatings, and characterizes the finished coatings. All of this runs fully automatically according to a precisely defined program that can be reproduced at any time. As a result, the unit can formulate an average of 120 samples in 24 hours. The results can be called up and reproduced at any time. If this data is linked with COATINO™, customers will receive daily updated data about individual coating formulations.



Additives give coated **leatherwear** an especially supple feel

“The usual assistants simply can’t understand our language”

OLIVER KRÖHL, HEAD OF THE COATINO™ PROJECT



The right additives support **printed textiles'** fastness to light and washing, and bring colors to life

“They have to be able to do a lot more in order to formulate a coating,” says Kröhl. “If they don’t know the components’ properties and how they interact, they won’t be any help in the laboratory.”

PREVENTING FOAM, SCRATCHES, AND RUNS

Paints, lacquers, and other coatings basically consist of four components: solvents, binders, pigments, and additives (see graphic p. 36). A solvent keeps a wall paint in a liquid state, for example. The solvent evaporates after the paint is applied, causing it to dry. Pigments give the paint the desired color. Binders are used to ensure the paint remains attached to the wall and is effective. This component is colorless and bonds the →

paint with the substrate. Additives make up the smallest percentage of a formulation. Although their share is less than five percent, they nevertheless play a key role. Additives eliminate foam when paint is applied. They also prevent the paint's pigments from agglutinating. They make coatings thixotropic, i. e. they make them easy to apply, but prevent them from forming runs when they dry on vertical surfaces. Other additives make coatings more scratch-resistant, for example.

The various components influence each other's effects, depending on the mixture. The number of possible combinations is immense. Even if only ten curing agents, ten binders, ten pigments, and ten additives are considered during the development of a coating recipe, these numbers translate into 10,000 possible combinations. And this doesn't even take into account varia-

tions in the ratios of the components used. "Customers have very precise ideas about the capabilities that a product should have once it's finished," says Blanda. In order to develop a functional voice-controlled assistant for the coatings industry, the researchers at first began to structure all of the available information and feed it into a huge database. In the next step, they made it possible to call up this information using a voice-control function.

TRAINING FOR GLOBAL APPLICATION

For example, if you ask the assistant, "Which additive is suited for printing ink?," the system obviously has to be able to understand each word. Among other things, COATINO™ had to learn that "additive" designates a certain category of coating components. In the next step, the assistant has to access its data, search through it, create suitable links, and assign the data to a possibly relevant result. To do so, it first breaks down the sequence of sounds into their smallest components and conducts a data search on the basis of characteristic properties. A special challenge for the assistant is that COATINO™ has to be able to understand not only German nouns in the nominative case but also in other cases. The researchers also want to make sure that the speaker's dialect or accent won't hamper the result. The ultimate aim is to enable COATINO™ to understand customers' pronunciations worldwide. Added to these challenges are the speakers' different talking speeds and pitches as well as the specific context of a discussion. "The training process is very nerve-wracking," says Kröhl. "And after the trial run with our colleague in Shanghai was finally successful, it went wrong with our colleagues in Essen." For almost two years now, COATINO™ has been jointly developed and trained by the business line and an external development company from Berlin. The assistant passed its first important development test when the prototype was demonstrated at the ECS.

COATINO™ has a lot of things it can say. When asked about suitable additives, it not only presents a list of products but also prioritizes them. "COATINO™ can tell me which additive would be best suited for my formulation and my requirements. It can thus give me well-founded recommendations," says Blanda. Once a user has found the desired product, he can issue a voice command to tell COATINO™ to order a sample,



Silicone-based hydrophobing agents for **architectural paints** reduce water absorption and produce a pearl effect



Additives used for **food packaging** enable even ink application and a premium appearance

directly call up the pertinent technical data sheet by e-mail or have a conversation with an expert arranged. “For us, customer-oriented digital solutions enable people to talk with one another more efficiently about innovative solutions,” says Kröhl.

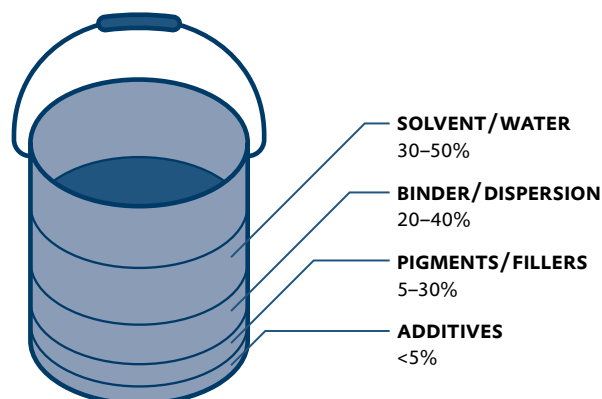
NEW FORMULATIONS FROM THE DATABASE

The COATINO™ prototype was ready just in time for the start of the European Coating Show. “We immediately presented it to a select group of our customers,” says Blanda. Instead of a can, the users imparted their wishes to a tablet via a microphone. “The feedback was even better than we’d hoped. We were able to gain some of the customers as first users who will test the assistant.” They will pass on their experiences to Blanda and his team. “We wanted to get the customers involved at an early stage,” says Blanda. “Such a project can only work if customers also think it benefits them.” In 2020 the researchers plan to make COATINO™ available for the entire coatings industry.

However, there is no end in sight for the system’s further development. “When you use digital assistants, you continually come up with ideas for new features,” says Kröhl. For example, COATINO™ could conceivably not only supply existing formulations but also suggest its own new mixtures. The scientists could directly test these mixtures in the lab and enhance them for their own use. “Our COATINO™ might one day really become an artificially intelligent entity,” says Blanda. “But we still have a long, long way to go until then.”

A VARIETY OF COLORS

The most important components of a pigmented coating





Bright prospects: Norway's success is based on valuable raw materials, a knack for innovation— and smart investment

This Scandinavian country is systematically investing its export earnings in future-oriented technologies. The Norwegian market offers Evonik numerous points of contact and attractive growth potential

TEXT **NICOLAS GARZ**

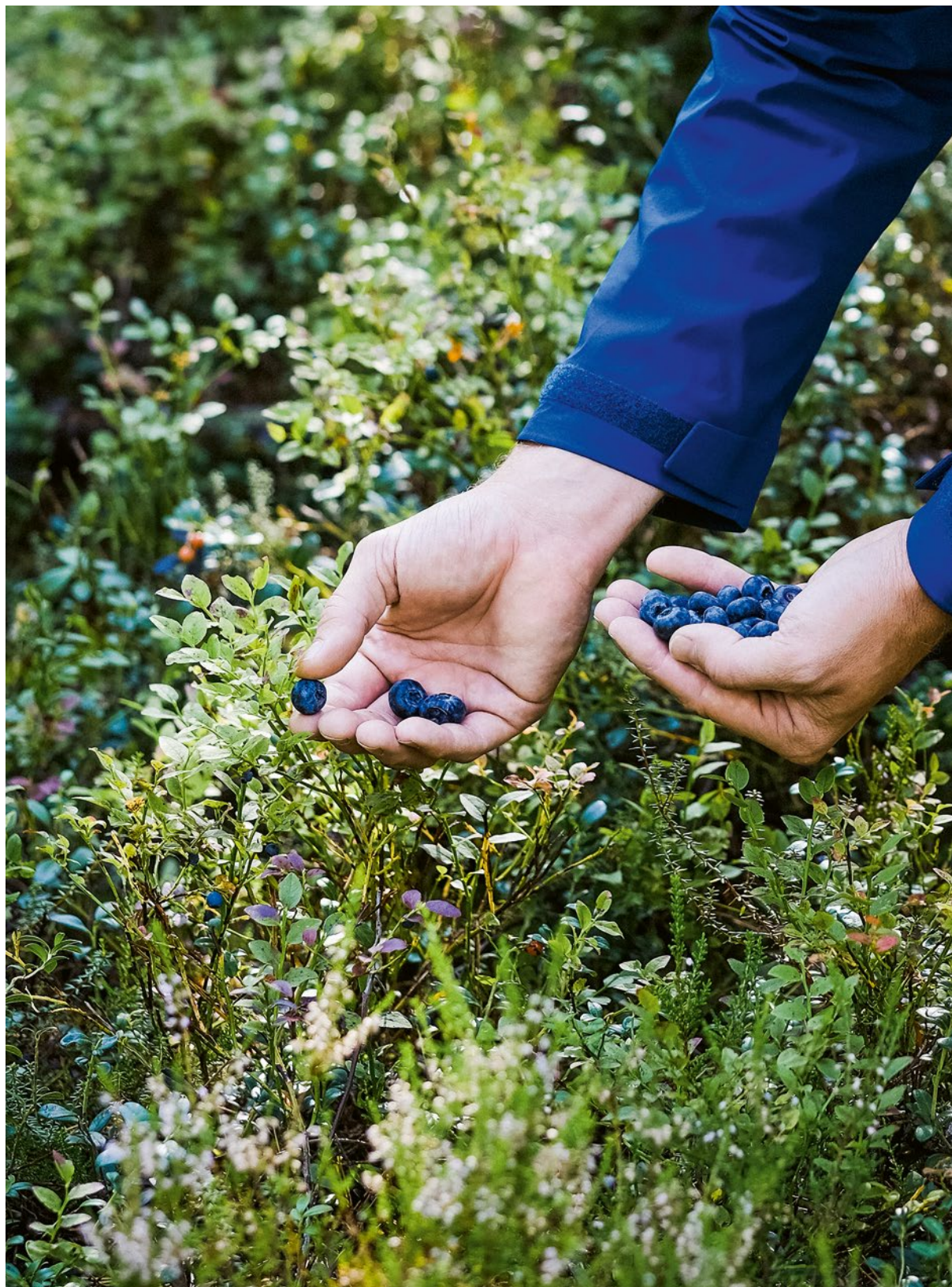


— The fjords of Norway offer more than just breathtaking views. They also make it possible to sustainably breed salmon, one of the country's leading exports. In order to halt overfishing in the world's oceans, Norway has been promoting salmon farming for years. Its fjords are ideal for salmon breeding, and the net cages offer the fish a natural environment. The salmon are well-fed thanks to Veramaris, a joint venture of Evonik and DSM that supplies omega-3 fatty acids derived from algae oil for fish food.



■ Electromobility: On Norway's roads, electric vehicles are no longer an exotic species. Today half of the country's newly registered vehicles are already powered by electricity. From 2025, no new gasoline or diesel-powered vehicles will be registered in Norway at all. Reaching this goal will require a sufficient number of charging stations and powerful lithium-ion batteries. Chemistry will play a crucial role. For example, AEROXIDE® from Evonik enhances the capacity, safety, and service life of batteries.





■ In late summer in Scandinavia, black and blue glints along forest paths signal that the berries on blueberry and currant bushes are ripe and ready to pick. Besides looking delectable, the berries are good for your health. Their natural colorants, called anthocyanins, have positive effects on the heart and the blood vessels. Evonik offers an extract of these berries as a diet supplement under the name of MEDOX®.

There's no contradiction here: The Norwegians, who are used to minus temperatures, provide heat all over the world—as the third-largest exporters of natural gas. The gas is transported via pipelines that need to be especially robust. Polymers from Evonik play an important role in the production of these pipelines. They prevent corrosion and ensure that the natural gas can flow safely from A to B.





■ Norway is known as the country where skiing was born. The first modern-style skis were made in Telemark around 1860. Back then they were comparatively simple wooden boards. Today all winter sports equipment is full of high-tech materials. For example, polyamide 12 is a plastic that enables ski boots to withstand extreme stress conditions. And ROHACELL® rigid foam makes skis both resilient and lightweight. These are ideal prerequisites for a safe downhill run – the skier's skills will take care of the rest.



**FLYING HIGH
IN THE NORTH**

Healthy nutrition is the focus of Evonik's current operations in Norway: In the city of Sandnes, the Group produces MEDOX®. Norway is also important as a promising market. With its products Evonik is promoting Norway's future viability in the areas of raw material extraction, technological innovation, and ultramodern infrastructure.



Evonik has

23

employees at

1

Norwegian location

SKIN DEEP

Our skin protects us from cold, heat, radiation, and pathogens. Injuries to the skin require a fast response. At its Tissue Engineering Project House Evonik develops innovative materials and processes to improve growth of tissue in the laboratory, which may allow the establishment of new therapies to heal human skin

TEXT **MICHAEL STANGE**

The hope of millions of people is barely visible to the naked eye. Only 10 to 15 micrometers across—ten times thinner than a human hair—these skin cells are surrounded by a liquid carpet of nutrients, salts, sugars, trace elements, and amino acids. There's a total of over 300 ingredients, but no one knows the cells' favorite recipe in its entirety. Not yet. But if cells are to multiply, that is exactly what's needed. It's a recipe that could improve the lives of people all over the world suffering from severe burns or open wounds. This is why Evonik scientists are studying new materials for culturing cells and growing artificial tissue.

The researchers in question are part of the Tissue Engineering Project House, which Evonik established in Singapore. The name refers to an interdisciplinary field of research encompassing engineering and chemistry fundamentals on the one hand and biological sciences on the other. The goal is to develop the next generation cell nutrition ingredients, carrier materials and cultur-

ing processes which will allow the industry to commercialize biological replacement materials that will restore, maintain or improve tissue function.

A GLOBAL TEAM

Through the Tissue Engineering Project House, Evonik aims to better understand how to use cells grown in culture for producing man-made biological tissue and to develop novel solutions. "Both for non-medical purposes and for innovative therapeutic approaches—regenerating human skin following accidents or disease, for example," explains Alexander König. A chemist by education, 38-year-old König has worked at Evonik for four years, and one year ago was given the opportunity to direct the new project house. Two weeks later he was on a plane bound for Asia.

König has since traveled regularly between Singapore, the USA, and Germany, coordinating the international team. In Singapore, up to 20 Evonik research- →





Cells are stored at temperatures around -196°C

ers from different units within Evonik work closely with colleagues in Birmingham/Alabama and Darmstadt, where Evonik has already developed extensive competencies in the fields of medical and cosmetic applications (see infobox). König and his team are to work for at least three years on new functional materials, processing technologies, and even methods for culturing tissue types. Cell therapy is one focus for the team; artificial skin is another.

MANY OPEN QUESTIONS

“Singapore has top universities and lots of experts in applied biomedical sciences,” says König. “We work on several open questions. That’s why we need access to experts from a wide variety of disciplines.” One of these experts is Zee Upton. As the head of the Institute of Medical Biology at the Agency for Science, Technology and Research (A-Star) in Singapore, the 56-year-old biochemist conducts internationally renowned research in the field of wound healing and tissue growth

“There would be interesting applications for our customers in the pharmaceuticals and cosmetics industries”

ALEXANDER KÖNIG,
DIRECTOR OF TISSUE ENGINEERING PROJECT HOUSE

and repair. “Chronic wounds such as diabetic foot ulcers, venous leg ulcers, and bedsores are a huge health problem,” she says. “Two to six percent of the world’s population suffers from them.”

Upton is calling upon researchers to intensify their search for the best possible ways of treating chronic wounds. Although specialized dressings and bandages are available, she remarks, “there’s no satisfactory treatment for healing chronic wounds.” Upton’s com-

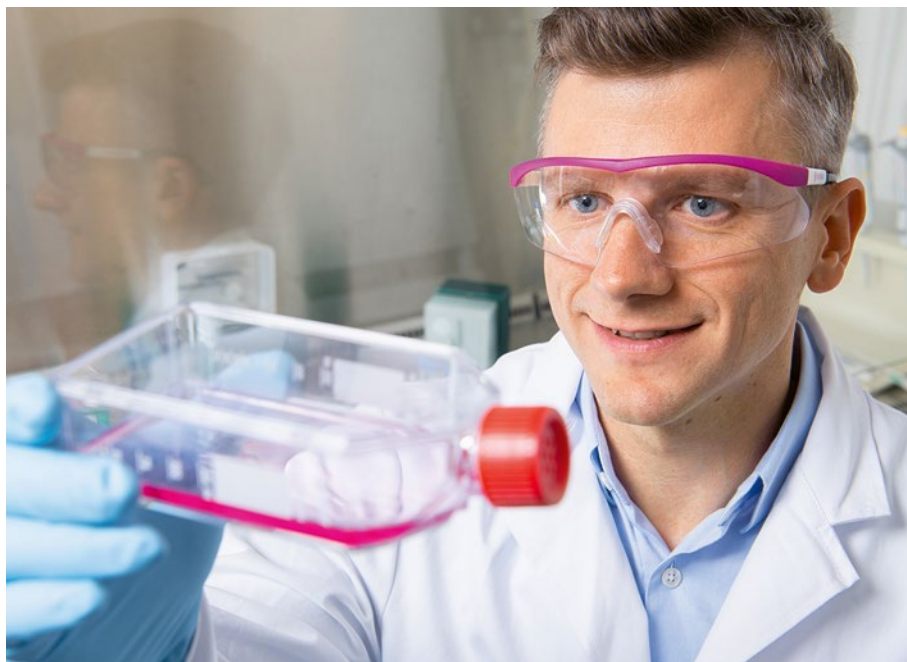
ments reflect just one of many challenges that could be tackled with the help of tissue engineering—challenges that the researchers at the project house are now addressing.

AS REALISTIC AS POSSIBLE

One goal of the scientists is to use cells grown in culture as a basis for creating artificial tissue that would mimic its natural counterpart—the skin—extremely closely. Their plan involves different types of human cells interacting just as they do in the body. The most realistic possible model of the skin would need to contain the two layers of the epidermis, or outer layer of skin, and the dermis, or corium, below that—and ideally even 3D-printed blood vessels that would supply the laboratory tissue with adequate oxygen and nutrients. “If we can do that,” says König, “researchers like Zee Upton won’t be the only ones to benefit—there will be interesting applications for our customers in the pharmaceuticals and cosmetics industries too.” Among these applications are new approaches to using cell therapy for wound healing, skin models for in vitro testing, and culturing transplants from the patient’s own cells—the greatest challenge

But first things first: cells—or even skin tissue—grown in culture in the lab could be used for novel cell therapies for healing wounds. This would involve taking a patient’s cells and culturing and/or multiplying them in vitro. The cells would then be reintroduced to accelerate the healing of the damaged organ—the skin in this case.

The next application, i.e. skin models, would be to create replicas of the skin that are as realistic as possible and that would only be used for research and testing purposes. While a few commercial providers are already selling this kind of laboratory-grown tissue, “Those products don’t yet mimic reality well enough,” König points out. “A lot of test results can’t be correlated one-to-one to human beings.” In many models, the protective barrier is around 100 times more permeable than is the case in nature, and the dermis lacks blood vessels. Evonik hopes to help optimize skin models for more reliable results when it comes to testing new medications, cosmetic agents or cleansers. →



Alexander König checks the solution, which consists of a carrier material and a culture medium in which skin cells reproduce

i The foundation on which project house researchers can build

The Tissue Engineering Project House represents another step in Evonik’s efforts to strategically develop its activities in the field of medical applications. The former Medical Devices Project House is now an established competence center unlike any other in the world. Its focus is on developing new biocompatible materials and the technologies for processing those materials to make implants for orthopedic and cardiovascular applications. A range of products has already been successfully positioned on the market, and the team at the Tissue Engineering Project House can now build on that work through its focus on growing entire tissues artificially. The research work is complemented by technologies and products from Evonik that have been established for years. These include amino acids and derivatives produced without the use of animals as well as the additives (known as boosters) that Evonik makes for animal-free, cell-based production of biological actives and the company’s expertise in cosmetics testing and skin models.

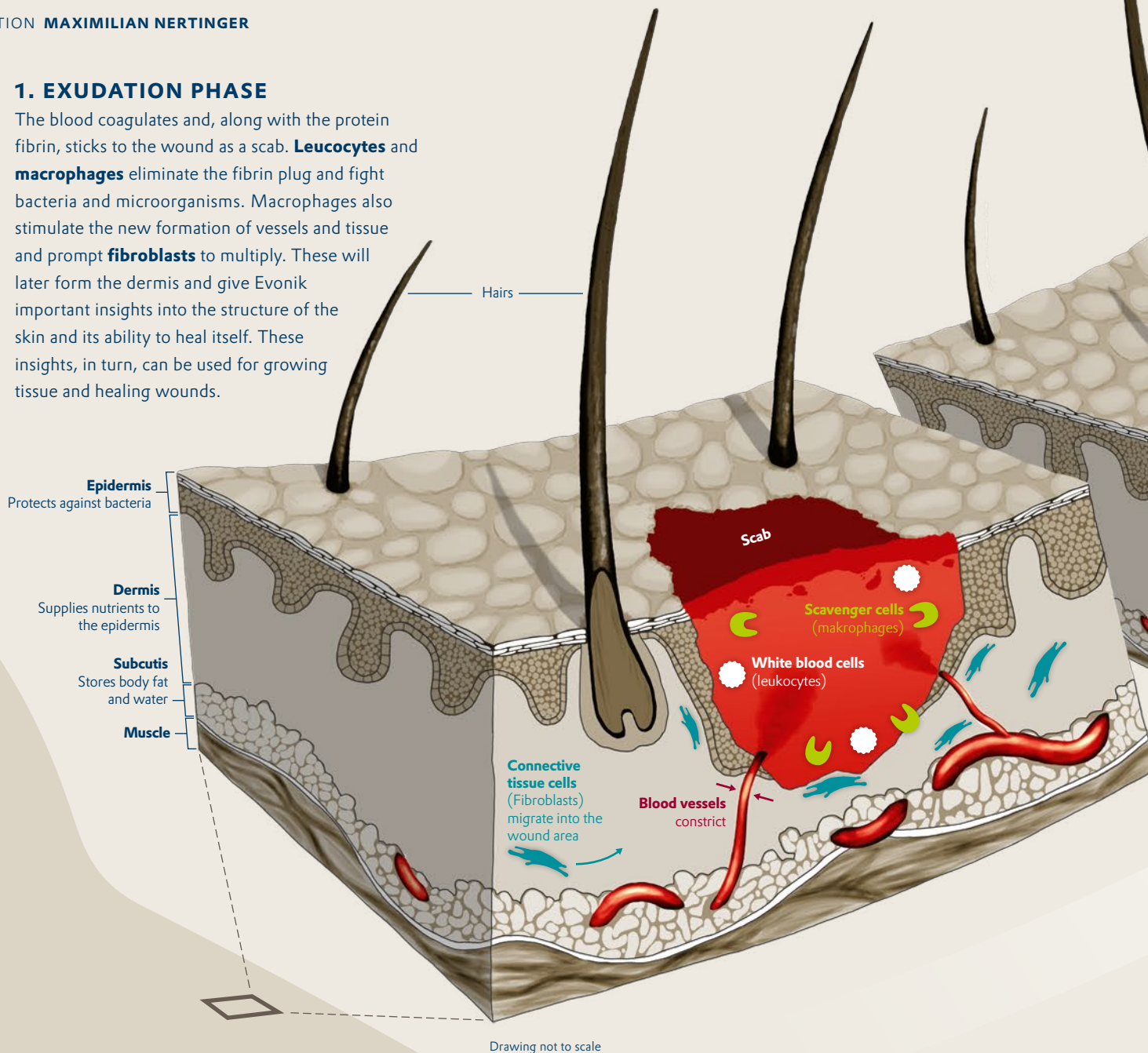
An emergency team that gets under your skin

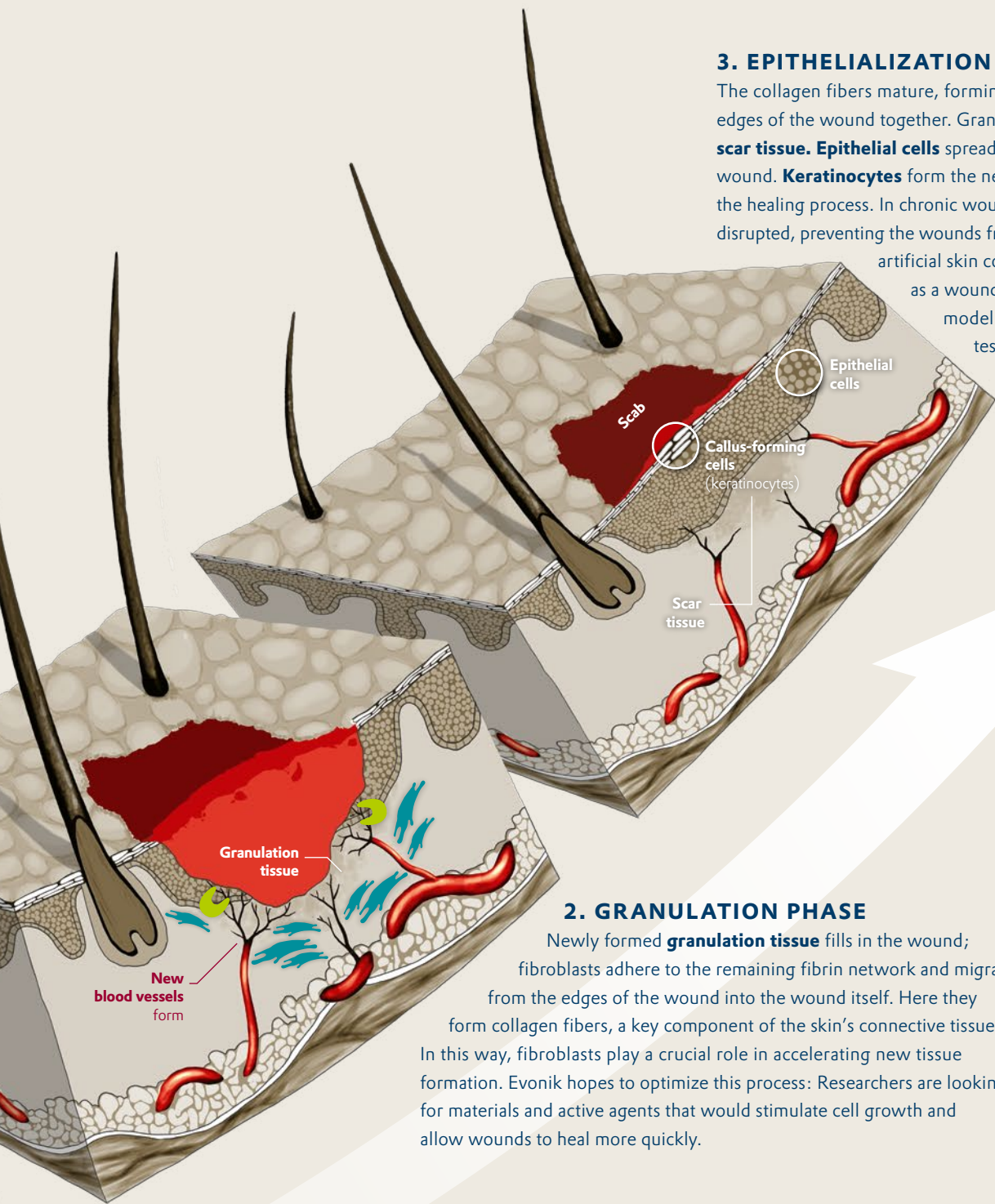
When the skin is damaged, the body launches an emergency response that ideally ends with a fully healed wound. But what actually happens in this process, and how can research support the body's efforts? An overview of the three phases of wound healing

ILLUSTRATION MAXIMILIAN NERTINGER

1. EXUDATION PHASE

The blood coagulates and, along with the protein fibrin, sticks to the wound as a scab. **Leucocytes** and **macrophages** eliminate the fibrin plug and fight bacteria and microorganisms. Macrophages also stimulate the new formation of vessels and tissue and prompt **fibroblasts** to multiply. These will later form the dermis and give Evonik important insights into the structure of the skin and its ability to heal itself. These insights, in turn, can be used for growing tissue and healing wounds.





3. EPITHELIALIZATION PHASE

The collagen fibers mature, forming a network that pulls the edges of the wound together. Granulation tissue converts to **scar tissue**. **Epithelial cells** spread across the surface of the wound. **Keratinocytes** form the new epidermis and complete the healing process. In chronic wounds, however, this process is disrupted, preventing the wounds from healing. This is where artificial skin could help: as a transplant, as a wound dressing or as a laboratory model on which Evonik could test substances for their impact on wound healing.

2. GRANULATION PHASE

Newly formed **granulation tissue** fills in the wound; fibroblasts adhere to the remaining fibrin network and migrate from the edges of the wound into the wound itself. Here they form collagen fibers, a key component of the skin's connective tissue. In this way, fibroblasts play a crucial role in accelerating new tissue formation. Evonik hopes to optimize this process: Researchers are looking for materials and active agents that would stimulate cell growth and allow wounds to heal more quickly.

FACTS ABOUT SKIN

The skin is a true multitalent: water-repellent and breathable, cushioned and climate-controlled, self-healing and razor thin. The skin...



...covers **two square meters**, making it the largest organ in the body



...weighs **14 kilograms**, accounting for roughly 20% of our body weight



...renews **every four weeks**



...loses **600,000 flakes an hour**, which accounts for 70% of the dust in our homes



...possesses **three million sweat glands**, which excrete up to 10 liters of perspiration a day.



...contains **seven kilometers of blood vessels**



...is home to **ten quadrillion bacteria**, most of which live in our armpits.



...is **thicker and fatter in men than in women**, which would have once been important for hunting



...contains the following in a **single square centimeter**:

- Three million cells
- Four meters of nerve fiber
- 100 sweat glands
- 15 sebaceous glands
- 5 hairs

“The cells have to feel like they’re in their natural environment”

ALEXANDER KÖNIG

Yet another development—one that could be used in applications such as transplants—might conceivably come from this research as well. This is another area where some initial successes have been achieved: as early as 1993, Japanese researchers at Kitasato University were the first to grow replacement skin and to transplant it successfully onto a man’s burn wound. “But we still haven’t established methods or materials that would be easily reproducible,” König observes.

The reasons why none of the three applications have been successfully standardized to date are as varied as they are complex. Developing and culturing man-made

biological tissue are expensive, complicated processes due in no small part to the complexity of the skin. Skin is the largest organ of the human body, and contains roughly 120 billion cells. The different cell and tissue types have to work together with the top two skin layers to protect the body from pathogens, heat, cold, and UV radiation. Even a copy from the lab would have to serve those functions.

FROM THE CELLS TO THE PIECE OF SKIN

Cells need to do more than just proliferate in the laboratory—they also have to organize exactly the way they would in the human body, and to do that they need the right mix of nutrients, growth factors, and a scaffold. The nutrient solution with all of its ingredients—the cell culture medium, in other words—is first heated to 37 degrees Celsius, because cells feel most comfortable at body temperature. The scientists then dispense the liquid into plastic dishes coated with a gel-like scaffold material, onto which they pipette the cells, one type of cell per dish. The keratinocytes become the epidermis, or top protective layer of the skin, while the other cell type—the fibroblasts—forms the dermis below that. Once they are in their respective dishes, the cells are fi-



Researchers can use a 3D printer to print blood vessels, among other structures, from a variety of materials

nally placed in the incubator to mature and multiply. As soon as enough cells have formed, the researchers combine the cell types into a two-layer model while adding growth factors. After that, it's back to the incubator for two to three weeks until the cells have joined to form a firm, transparent skin the size of a one-cent coin.

"Our first aim is to simplify and speed up this drawn-out process," König says. "A lot of the steps have to be carried out manually. That can cause the product to vary—and that jeopardizes reproducibility." This risk rears its head in another area as well: the material.

"The current standard is for both the carrier and the nutrient solution to be based on animal products. That causes the composition to vary from batch to batch, which makes it difficult to obtain government approval for clinical applications." The effects on research are so far-reaching that they sometimes slow down the culturing process considerably or even ruin the specimen entirely. Moreover, products derived from cows, such as the bovine serum often used in the nutrient solution, harbor the risk of contamination with pathogens such as the one that triggers BSE (bovine spongiform encephalopathy).

"That's why we're working to optimize the materials we use in addition to developing innovative methods," König notes. Chemically produced synthetic materials can replace animal products if they are suitably biocompatible and have the right mechanical and physical properties. "When the cells are on the carrier material, for example, they have to feel like they're in their natural environment. Thus what we need is a functional material that stimulates cell growth and that we can modulate depending on whether we're growing bone or skin cells, for example."

GLOBALLY UNRIVALED COMPETENCE CENTER

This is where König and his team can draw upon know-how that has already been successfully developed by their predecessor—the Medical Devices Project House in Birmingham, which is now an established, globally unrivaled competence center in this field. Examples here include the production and processing of biocom-



Watching the development of the cells, which are just 10 to 15 micrometers across—requires a microscope

patible plastics. "At the Tissue Engineering Project House, we can use the knowledge they generated on medical devices such as implants, and then develop it still further," says König.

Evonik's portfolio also includes another foundation for successful cell culturing: For many years now, the company has been supplying manufacturers of cell culture media with amino acids and derivatives that are produced without the use of animals. Over the past few years, Evonik has also expanded its business in performance-enhancing additives for the cell-based manufacturing of biological active agents. "Here we have already successfully switched to media with no animal-based components. Now we want to explore applying that step to the culturing of skin cells," König explains.

"Our vision is to take existing competencies, further research activities, and external expertise and to funnel these into efficient, reproducible solutions." Once the project house is that far along, Evonik intends to offer new carrier materials and nutrient solutions for commercial tissue culturing. "Ideally we would be able to play a part in fulfilling the hopes of millions of people for more effective therapeutic approaches," König says. —

IN MY ELEMENT



“I’d Like to Get People Hooked on Physics”



Dr. Matthias Salewski (30) used to investigate semiconductor nanostructures in the laser laboratory at TU Dortmund University, but today he stands in the spotlight and performs experiments on stage. In his role as “Professor Liebermann” he’s one of the creative thinkers behind the company “Die Physikanten & Co.,” which stages science shows all over Europe

PROTOCOL ANNA SCHRIEVER
PHOTOGRAPHY ROBERT EIKELPOTH

Nitrogen is often the central element in our shows. We use it in almost all our performances. It’s stored in a vacuum jug—it’s a liquid at a temperature of -196°C , but as soon as it’s exposed to normal room temperature it becomes a gas. We can use it to generate fountains that are meters high, explode objects, or form a gigantic cloud in fractions of a second. All of these effects look spectacular on stage and thrill the audience.

When I was a doctoral candidate at TU Dortmund University, I worked with nitrogen every day. I would chill semiconductor samples in cryostats so that I could investigate them. Today I have a doctorate in physics, but I no longer work only as a scientist—I’m also an entertainer. Admittedly, this is a rather unusual career trajectory, but back when I was

an undergraduate at the university I once saw a poster for the Physikanten. I was immediately electrified, and I applied to join the group. The Physikanten are a group of scientists, actors, and presenters who stage science shows all over Germany and the rest of Europe.

The job of conducting experiments in front of an audience was just right for me, because I had always wanted to perform on stage. I’m a huge comedy fan and a passionate Latin

dancer, and I love to perform in front of an audience. My first performance with the Physikanten was on the Open House Day at the Federal Chancellery in Berlin, where we hosted a workshop. I performed as a Physikant during the entire time I was studying, and today it’s my main occupation. What I especially love about my work is the fact that I’m getting lots of people enthusiastic about science, and physics in particular. Doing research at a university is often so specialized that only a few people understand it. At our shows, it’s completely different. —

Masthead

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The nature of probability is such

...that even improbable things can happen, according to Aristotle. More than 2,000 years later, this realization is more relevant than ever. Today our lives are being shaped by innovations whose existence we would not have thought possible a short time ago.

ELEMENTS doesn't think in terms of "improbable." This new issue presents several bold insights into the world of tomorrow—and shows how the probability of a successful future is growing.

2/2019 **Future**