

Creating Chemistry

Precious seeds

Weathering climate change – new varieties of old seeds can help.

Page 26

Our life in color

Insights into a vibrant spectrum that influences us more than we think.

Page 46

BASF'S SUSTAINABILITY MAGAZINE

Go full circle

How the circular economy is shaping a sustainable future.

Circular Economy

Gumdrop, a company based in London, England, makes recyclable products from waste.

20%

is the minimum share of recycled gum in the Gum-tec® compound.



The sole of the circular economy

Discarded chewing gum litters streets all over the world. But we could turn it into something useful. Gumdrop collects chewed gum and processes it into Gum-tec, a recyclable compound that can be used to make new products, such as the soles of these Stan Smith shoes from German sportswear company adidas. Other products from Gumdrop include pencils, coffee mugs and frisbees.



1 kilogram

of gum is used for every four pairs of shoes.

100,000 metric tons

of chewing gum are produced globally every year.

Dear readers,

What can we do to ensure a good life on our planet today and tomorrow? To me, this is one of the most important questions for the future. For this reason, all of us – business, society, and policy-makers – have to chart new courses together, because our planet has reached its limits. In mathematical terms, we would need a planet 1.7 times the size of the Earth in order to meet our needs for raw materials. This calculation does not add up. The take-make-dispose principle has outlived its usefulness. New ideas are needed to decouple growth and resource consumption. Nature shows us the way – raw materials grow, are being transformed and become nutrients again. This system is made up of cycles, and it does not produce any waste.

Our cover story presents innovative approaches to this subject. They demonstrate that growth and sustainability are not mutually exclusive. On the contrary, they create many new possibilities for the chemical industry. Think of electromobility, for example. In the future, we will have to recycle millions of batteries. Our aim is to recover valuable raw materials such as lithium, cobalt, and nickel. BASF researchers are passionate about making this work. In this issue of Creating Chemistry, you can also find out about other innovations that our company is developing in order to close cycles.

By means of the example of plant breeding, we show you how we use available resources to adapt to changed conditions: BASF utilizes old varieties for modern breeds. They can help to feed the world's growing population and withstand climate change.



I am convinced that a functioning circular economy makes a significant contribution to climate protection and goes hand in hand with the energy transformation – away from fossil fuels and toward electricity from renewable sources. BASF is pursuing a clear approach and setting the pace. We are consistently focusing on sustainability. Together with our customers and partners, we are driving the circular economy forward.

I hope you enjoy reading Creating Chemistry!

Dr. Martin Bruder Müller
Chairman of the Board of Executive Directors, BASF SE



Your opinion is important to us

You are reading the latest issue of BASF's Creating Chemistry magazine. What do you think of it? Which topics would you like to know more about? Write and let us know your opinions and ideas: creating-chemistry@basf.com



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Circular economy in focus

What would life be like in a **circular economy**? We look at how businesses are moving away from a take-make-dispose model toward more sustainable approaches. And what this means for people and the economy. **Pages 6–25**



In the Arctic, more than a million **seed varieties** are stored. Why old seeds are experiencing a renaissance. **Page 26**

“**Truth is out there waiting for us to find it,**”

says **Professor Mona Simion**, Glasgow University, Scotland, in our section: From different perspectives. **Page 40**



Mark Gutjahr, Head of Design at BASF Coatings, translates social trends into **colors** for automobiles that match the spirit of their times. **Page 46**



Energy for young minds – we accompanied **Food4Education** on their work at the elementary school in Ruiru, Kenya. **Page 54**

PHOTOS: ONE ARMY/HUGH COOMBS; SVALBARD GLOBAL SEED VAULT/RICCARDO GANGALE; PPR; BASF COATINGS (2); GORDWIN ODHIAMBO

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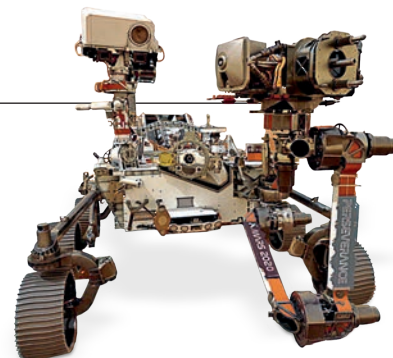
You cannot learn well on an empty stomach. Food4Education in Kenya shows that investment in nutrition pays off.

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Find out more about the world of BASF.



On an excursion with the **Mars rover**, and in a special submarine to the lowest depths. Come with us!

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Creating Chemistry online

Discover the online version of Creating Chemistry. Videos, interactive graphics, and much more supplement the topics of our print magazine.



basf.com/creating-chemistry-magazine



Focus

Infographic
How our needs are met
in a circular economy.
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Interview
Increasing prosperity
in a finite world.
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London, England



Fully edible

► RENEWABLE



Food sachets are as ubiquitous as they are difficult to recycle. The small plastic containers for sauces and condiments are highly convenient, but nearly always end up in general waste. Ooho sachets are an edible and biodegradable alternative made from Notpla, a material produced from seaweed and plants.





Chiang Mai, Thailand



Built with bamboo

▶ RENEWABLE



The sports hall at Panyaden International School is built using bamboo. It is faster growing than wood and sequesters carbon more quickly. Bamboo is also strong, flexible and light. Thanks to the bamboo, the school hall is carbon-neutral and has natural ventilation and insulation.

Thinking in circles

Imagine it is 2050. We have reduced carbon emissions to net zero and averted the worst consequences of climate change. The economy is no longer take-make-dispose but circular. What is life like and how do we get there from here?

PHOTOS: NOTPLA / JUST EAT / DC DAVIES;
CHIANGMAI LIFE ARCHITECTS

Hannah looks through her wardrobe and decides that she will wear her best trousers. They are more than 20 years old, but still in excellent condition because the manufacturer repairs and refurbishes them every year. There isn't much else in her wardrobe. She leases smart clothing when she needs it, returns other items when they are worn out to be made into new garments, or composts t-shirts herself when she's finished with them – they are fully biodegradable.

The products in her kitchen and bathroom are all in reusable containers. She could not imagine throwing away something as valuable as a plastic bottle. Her home is heated by excess heat from local industry, her fridge runs on reclaimed refrigerant. She 3D-prints her breakfast from yesterday's leftovers and sets off to work on an electric bicycle whose recyclable battery is recharged using renewable energy. Hannah works in a booming sector, developing algorithms that enable precise and efficient sorting of materials after consumers have used them. She does not think of this as waste.

In Hannah's future, no one would think it normal to throw away anything – clothing, electronics, household ▶

Cairo, Egypt



Digital credits for waste pickers

► REWARD



Half of Cairo's municipal waste is collected by informal waste pickers. To increase plastic recycling and support these workers, Nestlé Egypt and partners introduced a digital reward system. Pickers text how much they collect via SMS and receive credits in their e-wallets that can be cashed out every month.



Arnhem, Netherlands



Keeping clothes for longer

► REPAIR



Many people tire quickly of their clothes. Most end up in landfill. Fixing Fashion is a platform to share knowledge on how to repair, remake, resize and recolor clothes, keeping them in use for longer.



Higher-income countries account for one-third of all global resource extraction.

Source: Circularity Gap Report 2021

Focus

goods or food – until the maximum value has been extracted out of it. Materials are kept in circulation for longer by reusing, repurposing, refurbishing and recycling. Products are made for longer lifespans using fewer materials. Instead of acquiring goods, consumers increasingly opt for services to meet their needs. More of the goods in circulation are made from renewable sources with a low carbon footprint. What used to be seen as waste is now seen as a raw material. As it has value, it is collected and sorted and does not end up as litter in the environment.

Hannah's world is a circular economy in which consumption has been decoupled from resource extraction. It is a long way from today's world, where most waste is landfilled or incinerated, there is more discarded clothing than our systems can manage, electronic waste piles up in cities and plastic litters the oceans. In a world of finite resources, this should not be the picture. To get to Hannah's world we need to move from our linear economy to one in which we make better use of existing resources – a circular economy.

“The circular economy is a means to three ends: It will help reduce greenhouse gas emissions, preserve biodiversity and tackle inequality,” says Federico Merlo, Managing Director responsible for circular

“
It will take a big change in mindset to a more value-driven attitude toward consumption.”

Federico Merlo
Managing Director,
World Business Council for
Sustainable Development,
Geneva, Switzerland



Toronto, Canada



Giving food waste a new life

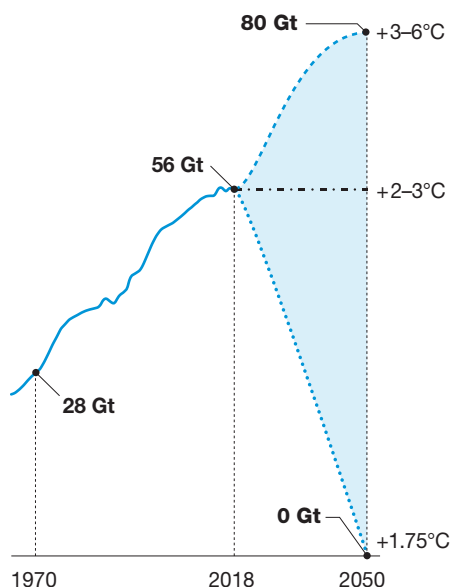
► RECYCLE



Genecis converts food waste into biodegradable plastics that can be used to replace single-use plastics. The material composts within a month. If it lands in the ocean, it degrades within a year.



We need a circular economy to tackle climate change



- Actual rise in greenhouse gas emissions in gigatonnes (Gt) of CO₂ equivalents
- Projected rise in emissions with business as usual
- - - If national climate pledges are implemented
- If, in addition, the global economy becomes twice as circular as it is today
- Range

Source: Circularity Gap Report 2021

be designed so that it is easier to recuperate material from them that can easily be reused in the same or other applications. People will dispose of waste into systems that sort and channel materials back into the value chain. Businesses will increasingly collaborate with partners to make that happen.

Creating better jobs

But just as important is the effect the circular economy can have on reducing inequality between countries. “The circular economy enables countries to grow gross domestic product using fewer virgin raw materials and less resource intensity. For emerging economies, it offers the opportunity to grow and create better jobs,” says Merlo. “If a system relies on intolerable labor conditions, that cannot be a sustainable circular economy.”

Perhaps the biggest change will be in our understanding of how we meet our needs and wishes. “It will take a big change in mindset to a more value-driven attitude toward consumption, seeing products in terms of where they come from and where they go, and making purchasing decisions on that basis. Businesses will find even better ways of providing services on demand without impacting the environment,” says Merlo.

The transition to a circular economy is already underway and many of the technologies needed to make it work exist. But there is a long way to get to Hannah’s world. Our world is currently only 8.6 percent circular, according to Dutch not-for-profit organization Circle Economy. And the international sustainability organization Global Footprint Network calculates that providing the goods and services we demand today requires the resources of 1.7 Earths. To meet climate goals, we must accelerate the transition to a circular economy. What are the next steps, where are the hurdles and how can we overcome them?

Continued on **page 14** ▶

Shaybah airport, Saudi Arabia 

Old runway makes new runway

▶ RENEWABLE 

Energy and chemical company Saudi Aramco refurbished one of its airport runways using rubblization. Special equipment is used to break up the old concrete so that it can form a new base layer for asphaltting.



PHOTOS: GENESIS; DPA PICTURE ALLIANCE/AHMED JADALLAH; WBCSD; GRAPHIC: JÖRG BLOCK

economy at the World Business Council for Sustainable Development, Geneva, Switzerland.

In terms of climate change, transitioning from fossil fuels will only get us part way to net-zero emissions; we need a circular economy to get the rest of the way. Scaling up circular models of production and consumption will also help restore nature. “With scale comes efficiency,” says Merlo. “Just as renewable energy is now largely cheaper than fossil fuels, so recycled materials will become less expensive than materials from virgin sources and that will translate into lower prices for consumers.”

Some end-uses have significant societal value even if second lives are unsuitable – like syringes for vaccinations. They will likely be made of reused, recovered or upcycled materials. Products will

Life in a circular economy

In Hannah's world of the future, people's needs and wants are met almost entirely through solutions that are part of the circular economy. Many of these concepts are already being implemented today and continue to be developed.



Digitalization – backbone of the circular economy

Digital technologies drive the circular economy by working out the best routes for resources to be reused or recycled. U.S. retail product cloud developer **EON**, for example, proposes a digital identity for retail products containing information about the materials they are made of. The data is embedded in the product and goes with it from production to sale, use, reuse and recycling. Starting with the fashion sector, EON plans to bring 400 million products online with its CircularID™ Protocol by 2025.

ILLUSTRATION: BJÖRN ÖBERG



Infographic

1

Food: Reduce

One-third of the food produced ends up as waste. In Australia, 7.6 million metric tons of food go to waste in the commercial sector every year.

→ **Yüme** in Australia is a business-to-business online marketplace for quality surplus products that connects suppliers with buyers. It describes itself as the eBay of surplus food.

2

Clothing: Reuse

New platforms for second-hand fashion connect buyers with sellers.

→ **thredUP** from the United States is one of several recommerce platforms aiming to meet this demand at scale with smart algorithms to determine prices. It can process some 111,000 items a day.

3

Health care: Refurbish

Medical equipment is too valuable to end up on a garbage heap.

→ **Philips** from the Netherlands refurbishes used medical equipment such as Magnetic Resonance Imaging Systems for resale.

4

Housing: Renewables

Architects and builders are increasingly looking to alternative materials for building construction to reduce the carbon footprint of our homes and offices.

→ **Biohm** from England has come up with an alternative insulation material made from mushrooms. Part of their roots are combined with synthetic by-products from industry to create insulation panels.

5

Electronic: Repair

Today, most electronic products are black boxes, sealed and inaccessible for repair.

→ **Framework Computer** from the United States has designed a laptop users can repair, configure and upgrade themselves.

6

Mobility: Share

The use of shared e-bikes and e-scooters in many cities is increasing, but they have to be collected individually by van for the recharging of batteries.

→ Chinese bike-sharing company **Hello Inc.** deploys over one million electric two-wheelers and has created a kiosk network where users can swap depleted batteries.

7

End of life: Recycling

The wood and cement used for burial and the energy for cremation have a substantial environmental impact.

→ **Recompose** from the United States has developed a process using naturally occurring beneficial microbes that break down the body in weeks. The resulting nutrient-dense soil can be used to enrich gardens.

Santiago, Chile



Reusable containers

▶ REDUCE



Social enterprise Algramo provides smart dispensing systems at retail locations across Chile, where customers can fill reusable bottles with as much cleaning product as they wish to buy and pay via an app.

Continued from **page 11**

“I once saw people cleaning up waste on a beach. All the time, more waste was coming in with the waves. It struck me that focusing on cleaning up doesn’t work. We need to start further upstream,” says Simon Widmer, Design Network and Creative Lead at the Ellen MacArthur Foundation, Cowes, England.

By “upstream,” Widmer means design. “At that stage, important choices are made about materials and the business model, which are hard to reverse later,” he says. These choices involve understanding the real need and seeing it within the whole system, says Widmer. It might mean not selling a physical product but providing a service or experience. There is no silver bullet. We will need different solutions depending on the context.

It also means thinking in a multi-disciplinary way, across value chains. “We need to reimagine the way we collaborate to address the real needs of people. Instead of creating value by extracting resources, we collaborate with a new set of partners to develop solutions that eliminate waste and pollution, circulate materials and regenerate nature,” says Widmer.

Changing consumer behavior

Many sectors are already adopting circular economy approaches, but there are challenges. The textile industry, for example, is a resource-intensive sector with a global value chain that generates a huge amount of waste. With the rise of fast fashion, global apparel production and

consumption appears to have doubled over the last 15 years.


“We need to change the way textiles are made, chosen and disposed of, to preserve the value of the materials we put on the market,” says Mauro Scalia, Director of Sustainable Businesses at EURATEX, the European Apparel and Textile Confederation, Brussels, Belgium.

A major challenge is how to get materials back into the value chain after the consumer has used them. EURATEX has launched the ReHubs initiative as an answer to this. “We are creating an integrated system of recycling hubs across Europe,”


says Scalia. “This aims at building new partnerships beyond the conventional textiles supply chain and engaging players from the chemicals industry up to retail.”

A further major challenge is price. “Consumers look for cheap products but sustainability has a cost and businesses need to be competitive,” says Scalia. “Most clothing choices are still based on comfort, aesthetics and price.” Although consumer awareness about sustainability is growing, there is still an attitude-behavior gap. According to German online clothing retailer Zalando, 60 percent of consumers say they want transparency, but only



Dearborn, United States 

Partnering across industries

► RECYCLE 

Automobile maker Ford and technology company Hewlett-Packard are working together to turn spent 3D-printed powders into injection molded components for some of their trucks.

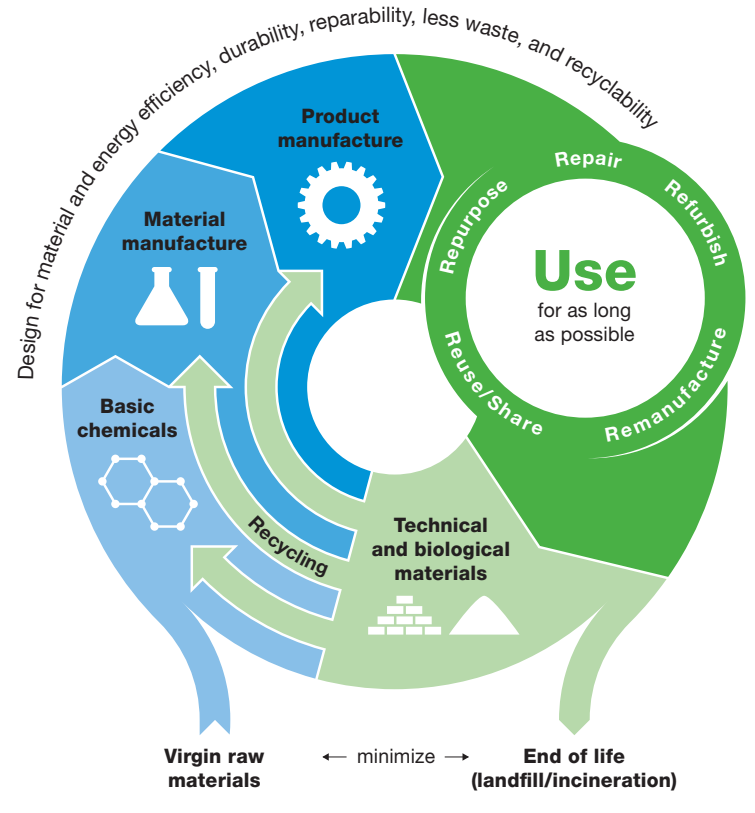
20 percent use this information when they make a purchase. Scalia says businesses need to find ways to facilitate more sustainable purchasing decisions and would benefit from clear, harmonized tools to inform consumers.

There are opportunities. “Quality and creativity are how many European businesses differentiate themselves. Sustainability is the new quality,” says Scalia.

Rethinking collaboration

For the chemical industry, too, the circular economy brings opportunities, challenges and new partnerships. ►

How the circular economy works



“Waste companies used to be the people we sent our waste to. Now they are potential raw material suppliers,” says Dr. Cordula Mock-Knoblauch, Director Renewables and Sustainability at BASF’s Intermediates division, Ludwigshafen, Germany. But whereas fossil fuel refineries produce standardized raw materials, that is not the case for those derived from waste. “We are working with waste companies to figure out the optimal feedstock for our industry,” says Mock-Knoblauch. “Can we use waste that is a mix of materials, or does it have to be sorted?”

Another question is how waste can be transformed into raw materials that easily fit into existing chemical industry value chains. One solution is BASF’s biomass balance approach, where biomass waste is used as a feedstock in the first steps of chemical production. “This approach enables us to increase the amount of renewable raw materials in our value chain more quickly,” says Mock-Knoblauch.

Bigger circles

While individuals and businesses can do their part, policies like the European Union’s Green Deal and Circular Economy Action Plan, or China’s plan to promote clean, recycling-based production methods and green design will also drive the transition. “Individual behaviors can have a tremendous impact. But behavioral change takes a long time, and change has to happen faster,” says Dr. Erika Bellmann, Head of Germany Programs at Bellona, a Norwegian non-governmental organization.

This is where government comes in. “We need a mix of quotas, norms and bans, as well as incentives and support schemes for new technology,” says Bellmann. “And we need infrastructure – a good waste collection system and electricity from renewable sources. That is important because the bigger recycling loops, such as chemical recycling, can require a lot of energy.”

A circular economy is more complex than a linear one. To optimize it requires tracking and tracing materials, feedstocks and residues throughout their life cycle. This is where digital technology can help to ensure waste streams are of higher purity and quality. “The more we know, the quicker



Uttar Pradesh, India



Preventing pollution

► REMANUFACTURE



Tons of floral waste from temples are thrown in the Ganges River every day, polluting the water with chemical residues. Phool collects the waste, cleans it, and makes it into new products, such as biodegradable packaging.

“
Change has to happen faster.”

Dr. Erika Bellmann

Head of Germany Programs at Bellona, Oslo, Norway





Shanghai, China

Learn new rules through play

► RECYCLING

Waste recycling became law in Shanghai in 2020. Instead of flyers and posters, the local government reached out to young people with gaming and virtual reality simulators to teach the new rules.

we can close loops and develop more sustainable products,” says Dr. Bernhard von Vacano, Senior Research Fellow at BASF, Ludwigshafen, Germany. It also supports sustainable design. Food packaging, for example, has to prevent leakage, protect the food, be recyclable or biodegradable and economically viable. “Simulation and big data enable us to predict early on which chemistry is likely to deliver all those characteristics,” says von Vacano.

Businesses also need to carry out a life cycle analysis for their products. One part of this involves every actor in a supply chain calculating their carbon footprint and handing the information on to others. “This is the basis for decision-making. That’s why we at BASF are calculating the carbon footprint for each of our 45,000 products. We won’t be able to find long-term sustainable solutions without this knowledge,” says Mock-Knoblach.

Is it possible to recycle resources forever? “In principle, but the energy required can outweigh the benefits,” says von Vacano. “It is hard to close a loop perfectly. Even if you keep 90 percent of material in the circle, after recycling ten times, only about one-third is left.” Another challenge is that products with a long lifespan will not be available for recycling for many years, so we need to find renewable raw materials to feed into the circles in the meantime.

A circular economy will not be perfect, but the current world is still far from circular. One of the most important drivers of change is personal leadership, says Merlo. “We have seen with the coronavirus pandemic that hidden enemies can bring us to our knees. With climate and inequality, we are facing even bigger challenges. Our leadership is needed now. We should all stop wasting time, because time is one thing that is not circular.” ■

Can you really recycle that?



Nuclear waste

Spent nuclear fuel could be recycled to make new fuel for specially designed reactors. The Pacific Northwest National Laboratory in Richland, United States, is working on separating out the usable energy-generating plutonium.



Satellites

There are thousands of bits of orbital debris circling the Earth, including broken satellites. On-orbit satellite servicing is an emerging field that extends the life of space equipment. European aerospace company Airbus is also working on ways to manufacture and assemble in space using disused space objects as a source material to 3D-print new parts.



Insulin pens

People with diabetes rely on insulin pens every day. Most end up in general household waste. Danish pharmaceutical company Novo Nordisk has found a way to separate the materials and recycle them into new products, such as office chairs.

Increasing prosperity in a finite world

Tackling climate change requires a radical rethinking of how the economy serves our needs. Professor Tim Jackson argues that to survive on a planet with finite resources we must move beyond a system based on perpetual growth.

Tim Jackson

Director of the Centre for the Understanding of Sustainable Prosperity (CUSP) and Professor of Sustainable Development at the University of Surrey, Guildford, England.

For more than 30 years, Jackson has led the debate on how to achieve prosperity on a finite planet. While Economics Commissioner on the UK Sustainable Development Commission in 2009, he published his groundbreaking book *Prosperity Without Growth*. His latest, *Post Growth, Life after Capitalism*, was published in March 2021.



For decades, economies around the world have pursued the goal of growth as a means of improving people's lives. But as our activities deplete ever more of the planet's natural resources and we get dangerously close to causing irreversible climate change, do we need to rethink what we mean by prosperity – to make it a goal we can achieve while staying within planetary boundaries?

Creating Chemistry: Your most recent book argues that the idea of pursuing growth is a myth that has become dystopian. Why is that?

Professor Tim Jackson: I believe we could be living in a better way if we did not have such a narrow focus on material wealth. I would replace it with the idea of prosperity, not as growth, but as progress of the human spirit, not as continual expansion, but as healthy balance. It's an idea that can be traced back at least to the Greek philosopher Aristotle. He asks the fundamental question about what the good life is, what it means to live well. He doesn't say to live well is to have more and more all the time. He says to live well is to have an appropriate balance. This is one of the lessons that we've learned during the pandemic – it is health rather than wealth that lies at the heart of our prosperity, and health is about balance rather than continually having more. It is about achieving quality of life, rather than simply quantity of output.

How do you sell the idea of post-growth to people who are still living in poverty or who aspire to a middle-class lifestyle?

The answer is that I don't. The evidence is clear that, in the poorer parts of the world, better incomes, safer and cleaner housing, better energy sources and cleaner water supplies all contribute massively to an increase in prosperity and quality of life in very basic ways. There is no doubt that there are places where some increase in income is a good thing. The question is whether this is a process that should go on forever on a planet with limited resources. Is it not the responsibility of rich economies to develop a different kind of economy that

isn't driven by more and more to allow space so the poorest in the world can afford to have enough?

Capitalism has been credited with pulling millions out of poverty and increasing standards of living in many parts of the world. Will this progress and innovation stagnate in a post-growth world?

I think it is wrong to assume that only the pursuit of profit will lead to innovation. Psychologists recognize two kinds of human motivation – extrinsic goals, such as money and status, and intrinsic goals, which are those deeply held desires for purpose and meaning that lead us to engage in social action, to solve problems, to dream of a better world. There is evidence that successful entrepreneurs ▶

Interview



CUSP's CYCLES project studies the lives of young people in seven cities on six continents to understand their lifestyles and aspirations and their ideas for living well within environmental limits.

Focus

are driven as much by intrinsic as by extrinsic goals. A post-growth economy could be richer in social innovation than a capitalistic economy that assumes only extrinsic motivations matter.

Why should a company pursue a post-growth agenda?

If your business model is predicated on the idea of continued growth and throughput, you are going to run up against environmental or resource-based limits. The impact material supply chains have on energy, climate, resources and waste places them at the heart of the change towards a sustainable economy that can operate within planetary boundaries. Businesses no longer operate in a world where resources are plentiful and the planetary impact is relatively small, so you need to be able to show that the value provided to society by what you produce is not undercut by the impacts that production chains are having on the environment.

What does this transformation involve?

Thirty years ago, when I started working on clean technologies, the focus was on the idea of a win-win – if you lose less materials out of the system you gain efficiency-based improvements. But today these simple efficiency models don't go far enough. One way is to ask, what is the service provided by this product? That draws you into thinking whether that service could be provided in some other way. Another way is the circular economy, which I'm deeply in favor of. But for me it doesn't stop with technological processes. It has to go a step further and ask whether what is being produced is in the service of human well-being – that's where a company's social license comes from.

Can digital advances in the form of the fourth industrial revolution lead to more sustainable growth?

Through digital technologies we can do things in better, more efficient ways. But this can also be dangerous. If wages and profits follow productivity growth, that means the people involved in these very clever technologies get very rich



What does it mean to live a good life within the ecological constraints of a finite planet? CJSP brings together people from all walks of life to develop new visions for prosperity.

“
I think it is wrong to assume that only the pursuit of profit will lead to innovation.”

very fast. If that's not transmitted through society in wages, then you begin to see a divided society.

What metrics should businesses use in your alternative model to measure success and attract investment?

People have in various ways tried to do this with ideas like the triple bottom line, that is people, planet and profit instead of the Milton Friedman mantra that the business of business is business. You could transform that idea into “the business of business is service, progress, purpose and the well-being of society.” When you talk to people who work in the most successful businesses on the planet, they want to engage in a discourse not only about accumulation of capital and status but also around purpose, human benefits



Art and culture are inherent to prosperity, according to CUSP. One focus is Finsbury Park, an area of rapid gentrification in London, England. CUSP is exploring the role cultural activities play here in understanding the good life.

so much on technology and equipment but on people's time in the service of each other. A post-pandemic shift to a green economy is partly about building efficient carbon-neutral technologies, but it is also about creating a society that is employment rich because we're investing in health and social care and the things that support the fabric of our society.

What kind of world do you want to see in 30 years' time?

We should be setting our sights on something richer and more fulfilling than the materialistic pursuit of accumulated wealth. It would be a much fairer world, in which people have more opportunities to enrich themselves by engaging in fulfilling work and play. There would be a stronger sense of community, better relationships, stronger societies and a cleaner environment.

What must we focus on to get there?

In studies, kids have told us they want a job in which they can make a meaningful contribution to society, yet we encourage them into a life that is materialistic, driven by technology, where you need a certain income to compete with your peers and to be in a comfortable situation. We should build an ethic of decency and service to society, where enriching society is the foundation for our shared prosperity. Windmills, solar panels and electric vehicles will matter. But it's the social quality of the future that I feel most passionate about. ■

and long-term progress. I think that sense of balance is needed at both the societal and the individual level. But it is difficult for it to be manifest in society because we've created institutions that legitimize the practices that lead to unequal wealth and accumulation at the expense of people and planet.

Are we measuring the wrong things in our economies as a whole?

A lot of measures are not fit for purpose. The biggest of those is gross domestic product. It is a good measure of the busyness of the economy, but it is not a good measure of the welfare of society. Some countries have begun to integrate broader and more meaningful metrics at the national level into their decision-making processes. For example, in New Zealand they use a living standards frame-

work. There are also attempts to adjust gross domestic product to take into account the depreciation of natural capital or to include some measure of inequality. The critical thing is how you use these measures as decision-making processes to orient the direction of your economy and your society.

There has been a lot of talk about building back greener after the pandemic. What does that mean to you?

People think it means investing in equipment like wind turbines and solar panels. But from a carbon footprint perspective, among the green sectors are those that provide safety, security, social care and education. The social resources that improve and protect our quality of life are green because they do not rely

A new way of seeing our business

At BASF, embracing the circular economy means not just rethinking materials and production processes, but also seeing our role in the value chain in a whole new light, says Talke Schaffranek.

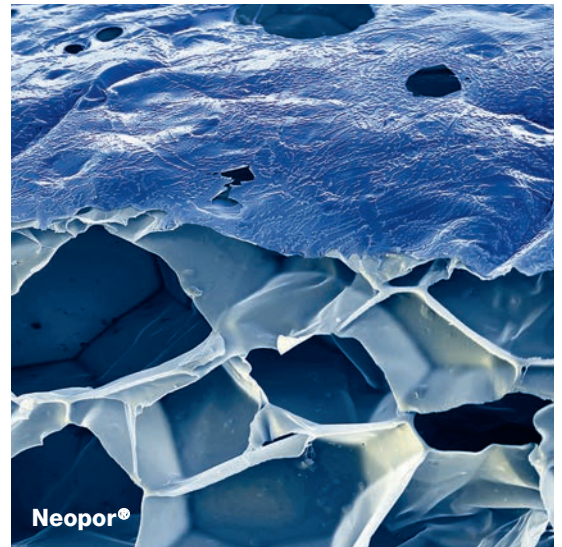
Moving to a circular economy means innovating not only our products but the whole way we see our business. For example, it means shifting from a model where we are paid for a product to a model where we are paid for performance – because this is one way to decouple growth from resource consumption.

But that's not all. We are also contributing as early as the design stage of products, with innovations that mean products can be made with fewer materials, are longer-lasting, or easier to recycle. We are taking responsibility for our products from beginning to end and closing loops with organic, mechanical and chemical recycling. And we are replacing fossil raw materials with renewable or recycled raw materials, like pyrolysis oil derived from plastic waste or old tires, thus preventing incineration. To drive this transition, we are working on digital approaches to track materials, collect and sort them economically and bring them back into the value chain.

If there is one term that sums up what we need next, it is systems thinking. We are at the beginning of the shift to a circular economy. In every industry, we need to not only rethink our own business, but also rethink who we work with and how.



Talke Schaffranek
Director Circular Economy, BASF



Neopor®



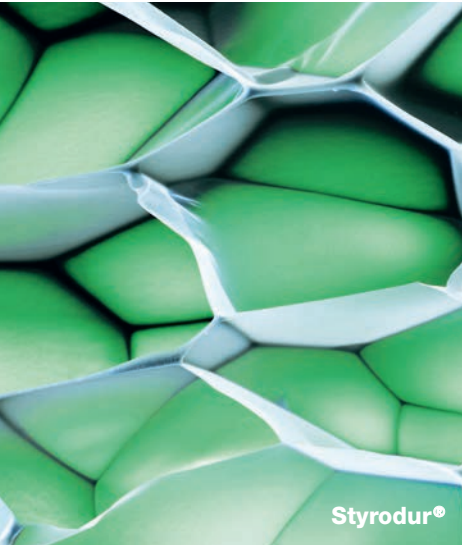
Oppanol®



Ultramid®

**Circularity
by BASF**

PHOTOS: BASF SE (6), GETTY IMAGES (SAXLERB, ALEKSANDRA AVERINA); BASF SE



Styrodur®

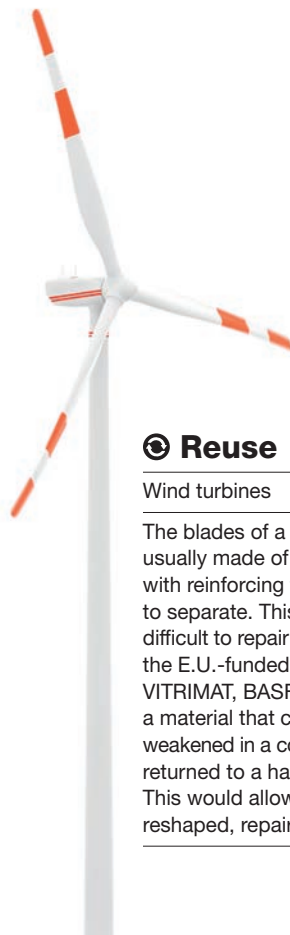
☻ Renewable

Biomass balance approach

The biomass balance approach enables BASF to shift from fossil to renewable resources quickly because it works within existing value chains. Bio-naphtha and biogas derived from organic waste are used as feedstock in the first steps of chemical production. The majority of BASF's portfolio, including insulation and hygiene products, as well as plastic applications for many industries, can be produced with this approach. The bio-based feedstock amount is allocated to each product following a certified method.



HySorb®



☻ Reuse

Wind turbines

The blades of a wind turbine are usually made of a strong composite with reinforcing fibers that are hard to separate. This makes the blades difficult to repair or recycle. As part of the E.U.-funded research consortium VITRIMAT, BASF is working on a material that can be chemically weakened in a controlled way and then returned to a hard and stable state. This would allow it to be reused, reshaped, repaired or recycled.



☻ Recycling

Lithium batteries

Over 1.5 million metric tons of battery cells from electric vehicles will have to be disposed of in the year 2030. These contain valuable resources such as lithium, cobalt and nickel. BASF is investing in battery recycling so that these raw materials can be reclaimed and reprocessed, and is part of the industry-led Global Battery Alliance, which is driving sustainability across the entire value chain.

☻ Reduce and recycle

Coffee cups

Food and drink packaging is often made of paper with a polymer film on it. Think of a takeaway coffee cup. The film makes the cup leak-proof, but because the two materials are bonded together, it is difficult to recycle. The two materials have to be separated and the polymer film disposed of. Some of the paper fibers are disposed of along with it. BASF has developed Joncryl® HPB, a heat-sealable liquid polymer barrier that is water-based. It can be used by existing systems to make leak-proof packaging. In many locations, the packaging can easily be repulped after use and recycled.



🕒 Three recycling processes

From plastic waste to new products



Mechanical recycling

Plastic sorting and PET recycling

Mechanical recycling is an important part of the circular economy. In North America, BASF makes Petra®, a thermoplastic polyester, out of post-consumer and post-industrial PET waste. For the process to work well, the material has to be all of one type. BASF subsidiary trinamiX provides a mobile, near-infrared spectroscopy solution that enables fast, on-the-spot identification of different types of plastics. Once sorted, they can be cleaned, shredded and reprocessed into new plastic products.



Depolymerization

Mattress recycling

What happens to old mattresses dumped at the curbside for collection as bulky waste? Often they end up in landfill or are incinerated. But through depolymerization the old polyurethane foam can be used to produce foam for new mattresses. BASF breaks down the material into its building blocks, the monomers, from which the polymers are rebuilt. Old mattresses provide the raw materials for the new ones, meaning fewer fossil resources are required.



Pyrolysis

Waste-2-Chemicals

In Lagos, Nigeria, plastic waste often ends up on the streets or in the ocean. Waste-2-Chemicals is a project run by BASF Nigeria with social entrepreneurs who collect plastic waste. Through a thermochemical process, the plastic waste is turned into pyrolysis oil. The oil is similar to naphtha and can be used by the chemical industry as a feedstock to make new products that have the same properties as conventional products. Pyrolysis requires more energy than depolymerization but it recycles mixed plastic waste. It can also be resource-efficient: A small part of the waste is pyrolyzed into gas and used to generate the energy for the process. In Europe, BASF uses pyrolysis oil as feedstock in its ChemCycling™ project.

Carbon

C

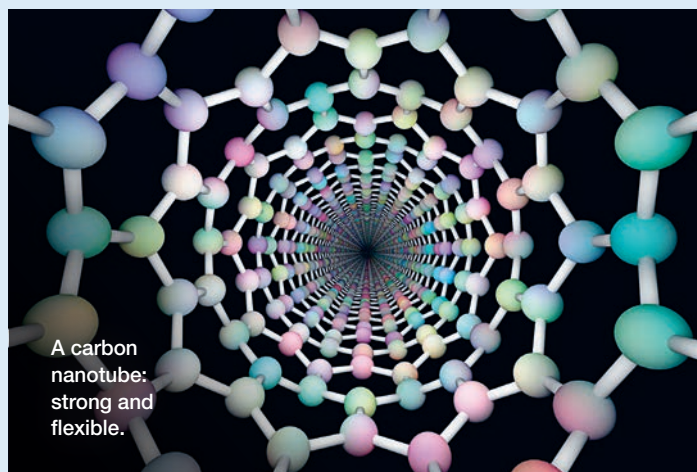
Atomic number
6

Physical state
Solid

Atomic mass
12.011 u

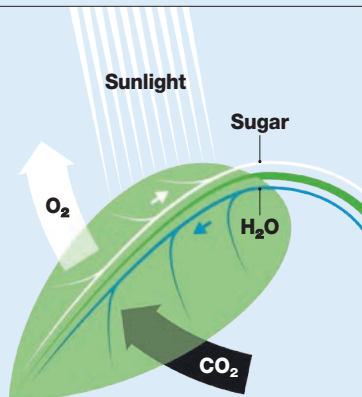
Occurrence
It is the fourth most abundant element in the universe.

Bond, carbon bond, is one of chemistry's most-used phrases. More than one million compounds have been documented; new ones are steadily discovered. So many, and so important are they, that C rates its own branch of chemistry: organic. The other 117 elements, when not linked to carbon, are all lumped together into the other main branch: inorganic. Carbon is the core of biology, present in all earthly beings. We literally breathe it. No carbon, no life. It accounts for 18.5 percent of human weight, second only to oxygen at 65 percent.

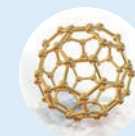


Life-giver

Thanks to **photosynthesis** you are able to live. It is an amazing yet everyday process, whereby plants convert light energy into chemical energy. Here's how: green plants take in carbon dioxide and water, then react these using the energy of sunlight. The result: sugar, which fuels and builds life, and oxygen.



Shape-shifter



Diamond, the hardest of all materials, can scratch anything. **Graphite**, perfect for pencils, is super-soft. Yet both are pure carbon. So too are **buckyballs**, or fullerenes, which are used as lubricants because of their

spherical shape. Such is the power of C-C bonds that carbon can take many forms and boast many properties. For instance, diamond is a great insulator while graphite is a great electrical conductor.

Climate-influencer*



Fugitive carbon

Fossil fuels and deforestation increase the amount of CO₂ in the atmosphere – temperatures rise.

Durable carbon

CO₂ can be trapped in wood, limestone, fibers, plastics, even empty oil and gas wells or deep-earth saline deposits.

Living carbon

Organic carbon, flowing in biological cycles, providing food, forests and soil.

Science & environment



Seeds of time

Old varieties of fruit and vegetables are in vogue. In the case of grain, too, more and more consumers are coming to appreciate the taste and nutritional richness of old varieties. Plant breeders see them as valuable resources for countering problems like climate change.

PHOTO: DPA/PICTURE ALLIANCE/REUTERS/LISI NIESNER;
ILLUSTRATION: ASCS/CLARA PHILIPPZIG

Organic meets high tech

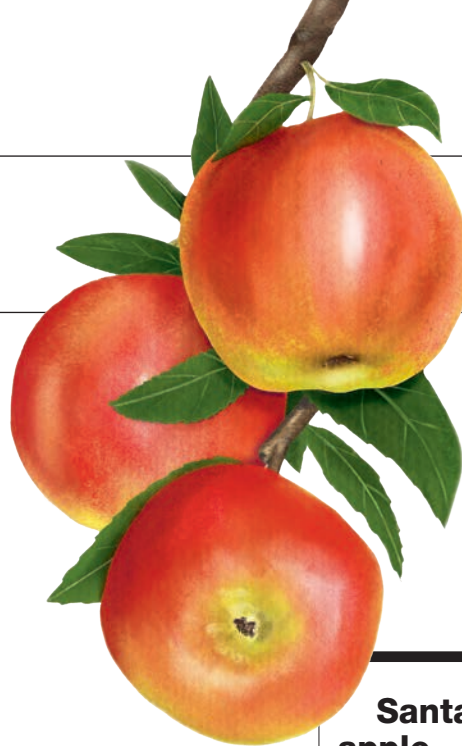
The trend toward natural cosmetics – and what lies behind it.

Page 32

Secret cleaning agents

Big cleanup with amines, robots, and the like.

Page 38



Santana apple

Some consumers have an allergic reaction to apples. Rashes and swellings are typical reactions to an apple intolerance. A new breed from the Netherlands offers relief. The Santana contains a lower amount of a protein that is considered allergenic.



The Vienna-based plant biotechnologist Margit Laimer is making the prehistoric *Silene stenophylla* champion blossom again after 32,000 years.

These cloverleaf-shaped white flowers extending a little cheekily from a short, green stem do look fresh – and yet, the seed of this plant that is thriving in the laboratory of Vienna’s University of Natural Resources and Life Sciences is 32,000 years old. It has survived for millennia in the Siberian permafrost. Researchers from the Russian Academy of Sciences made the plant grow again as a tissue culture in 2012. The team around plant biotechnologist Professor Margit Laimer then applied great skill and diligence to make the champion blossom again in a test tube in 2020. “This is a unique stroke of luck,” Laimer says happily. She now hopes to use genetic analyses to gain insights into how the genetic material in the champion developed – and how plants adapt to changing climatic conditions. This is an

important question for research in times of climate change.

Back to the origin of things is more than just a slogan for scientists like the researcher Laimer. Human beings seem almost instinctively to seek stability in biological and civilizational roots when faced with increasing threats. Old, almost forgotten plant varieties are experiencing a boom: bakery products made from ancient types of grain, like emmer or einkorn, are selling literally like hotcakes; and fruit and vegetables with a history, like the venerable German Gravenstein apple, are conquering weekly markets in the trendy quarters of major western cities.

The search for something authentic is usually about more than just romantic nostalgia, as old varieties can have tangible benefits for consumers, stresses Mark Sorrells, Professor of Plant Breeding and Genetics at Cornell ▶



Stenophylla coffee

This bean resists heat stress: *Coffea stenophylla* was cultivated in Sierra Leone until 100 years ago but was then displaced by the Arabica bean. According to researchers, Stenophylla coffee is also more resistant to rain – which means it may be able to withstand climate change.



University in the U.S. state of New York. Especially for people who suffer from the inflammatory celiac bowel disease, bakery products made from einkorn, an ancestor of spelt and wheat, could be more digestible than products based on modern, higher-yield wheat varieties. “These old grain varieties also have a more aromatic flavor,” Sorrells finds. Ten years ago, he launched a regional research project to find out what benefits the use of old varieties could have – not only for farmers and consumers, but also for restaurants and bakeries.

“We had to start virtually from scratch,” the geneticist explains. There were hardly any records to indicate which old grain varieties would flourish best in the soil and weather conditions of the Northeastern and Midwestern United States. The only solution: trial and error in the fields, which was often laborious.

What advantages do old varieties of crops have for consumers and the environment? Mark Sorrells from the United States, a professor of plant breeding, devotes himself with great passion to this question.



“When you request seeds from seed banks, you usually receive only three to five grams. This means it takes some time until you have enough seed to test one variety in the field,” he says. Once in the ground, the organically grown, rare varieties suffered from diseases such as loose smut. Ultimately, it turned out that although some of the old new grain varieties could indeed grow without difficulty in their own specific environment, they were of only limited suitability for baking. “Nevertheless, there are some varieties that are worthwhile using commercially, although not on a large scale,” Sorrells says.

Quality not quantity

This is not simple. The reintroduction of an old variety requires a finely coordinated, local mechanism made up of producers, representatives of the retail and catering

sectors, and consumers. One example of this interaction comes from New York State, where plant geneticists and restaurant operators pondered the question of which type of emmer would provide the best bite and flavor for pasta. It is a matter of quality, not quantity, Sorrells stresses, because old grain has a much smaller yield than modern wheat varieties. Often, the stalks are further apart, an individual plant has fewer grains, and these are usually enclosed in a hard, protective shell, the spelt, that is difficult to remove. Farmers, mill operators, bakers and cooks have to be trained in working with old varieties, and restaurateurs need to be schooled in marketing.

But Sorrells’ horizon extends beyond establishing local value chains. “Some of these old varieties have higher concentrations of provitamin A and contain more proteins than modern types,”



Just 9 plant species provide 66 percent of the global harvest.

Source: FAO

he says. However, these are precisely the kinds of micronutrients that could be important in the future in combating global malnutrition.

Securing food supply

“If food based on old varieties makes you feel better and you can afford it, then buy it! But it will not create global food security,” says Chike Mba, Team Leader, Seeds and Plant Genetic Resources at the United Nations Food and Agriculture Organization (FAO). Old seed types are hardly suited to meeting the FAO’s goal of increasing agricultural production by at least 50 percent by 2050, because their yield is too low, he explains. “Biodiversity is important,” Mba says, “but it must not become an end in itself. Nevertheless, it contributes to food security, especially when used as a starting-point for breeding highly developed crop varieties.”

Professor Edward Souza, Global Head of Wheat Breeding at BASF Agricultural Solutions, sees old varieties as a treasure that needs to be refined. “Our long-term goal is to use them for modern breeding, in order to feed the growing global population and to counter climate change. Therefore, we are systematically testing wild seed types and old varieties from historical collections,” he says. His eyes light up when he talks about the different colors and shapes of historical grain types. “You need to have seen that!” he says. “However,” and here his expression turns serious again, “they are difficult to cultivate.”

The breeding of hybrids, including those with properties of wild varieties, is complicated. Souza draws a picture of a pyramid to illustrate this: From countless varieties with different genetic features, BASF scientists, sometimes in collaboration with external partners, ►

Higher yields with hybrids

How hybrid breeding works

By selectively crossing two genetically different parent lines, breeders can combine – and even maximize – the best features of the parents in the subsequent generation (F1). Yield and quality, for example, can thus be optimized.

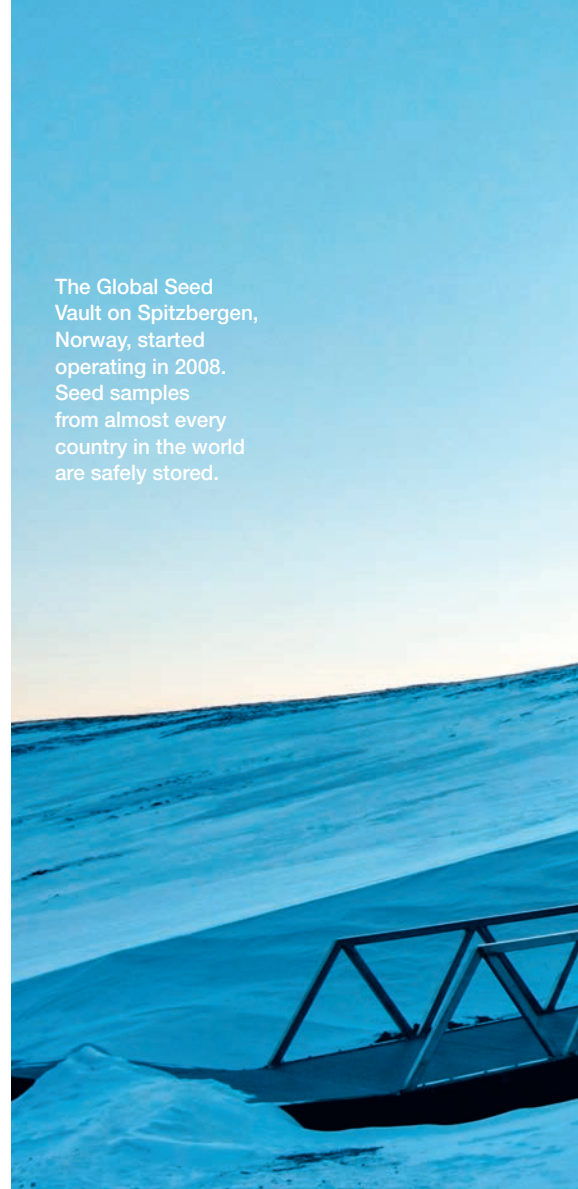
How widespread hybrids are

Hybrid plants are quite common in nature. Since the beginning of the 20th century, breeders also have been carrying out directed hybridization of cultivated plants. They are now widespread. The majority of plant-based foods – from tomatoes and carrots to corn and rye – is grown from hybrid seed. Hybridization of potatoes or wheat is still being developed. In the case of the latter, a milestone was reached in 2018 with the sequencing of its genome. It is five times as large as the human one.

BASF researcher Edward Souza uses the genetic diversity of old varieties to breed modern wheat that is better adapted to cope with climate change.



The Global Seed Vault on Spitzbergen, Norway, started operating in 2008. Seed samples from almost every country in the world are safely stored.



develop new, more effective varieties. In processes that last for years, they breed in desired properties until the apex ultimately contains varieties that combine particular qualities, such as good flavor, improved resistance and optimum yield. What makes hybrid breeding for wheat particularly difficult is that, unlike corn or rye, it is a self-pollinator. To prevent the mother line from forming any pollen, Souza and his team use a naturally present genetic sterility for effective cross-pollination.

The development of new hybrid wheat seeds like Ideltis™ from BASF involves the interaction of centuries-old routines in breeding with modern genetic analysis methods in the laboratory and computer-based prediction models. Souza and his team still have to test the new hybrids in several consecutive generations in field trials. They then undergo a two-

to-three year approval process – as in Germany, for example – before they can be sold. This means both breeding and market introduction are complex processes. Research on Ideltis has been carried out for ten years. By the middle of this decade, it is expected to be available to European and North American growers. In the breeding process, Souza stresses, his team focuses on a variety of wheat-breeding programs, in order to adapt plant properties to local needs. “We use old varieties in the development of hybrid wheat, so as to maximize quality and yield – this is why their preservation is important to us,” he adds.

Noah’s Ark in the ice

That is exactly the task carried out in a building rising up out of the expanses of an archipelago in the far north of Norway: the Svalbard Global Seed Vault, a project

Intense™ tomato

A team of breeders from BASF Nunhems, specialized on vegetable seeds, has developed a tomato that is particularly high in pulp and low in jelly. The Intense hybrid is designed to keep its texture, color, and aroma even after slicing and preparation.

PHOTOS: BASF SE; SVALBARD GLOBAL SEED VAULT / RICCARDO GANGALE; ILLUSTRATION: ASCS / CLARA PHILIPPZIG

Around 1.2 million samples are stored in the Global Seed Vault.

Source: Svalbard Global Seed Vault



whole Earth. Local breeders in need of seeds send their request to the nearest gene bank. Based on these, they create new varieties by crossing in properties from older seeds, which are then gradually archived again by the seed banks and kept in storage for future generations.

However, Schmitz says, there is a problem: genetic impoverishment. If you breed a plant with a focus on one particular, sought-after property, others will be lost. Schmitz describes the dilemma: “The more selectively bred it is, the less genetically diverse it will be.” To compensate for this genetic erosion, breeders try to re-cross the properties of the distant ancestors of these plants. Schmitz describes this as evolution’s eternal game of cat-and-mouse against pests that become smarter or resistant – but also against a changing climate. In this context, he says, who can know now which genes will be significant for the health and yield of a particular wheat variety in decades to come? This, he adds, is why the widest possible range of genotypes has to be kept alive at a global level, so that the preservation of plants like the prehistoric campion does not remain just a stroke of luck. ■

run by the Global Crop Diversity Trust, the Nordic Genetic Resource Center (NordGen) and the Norwegian government. However, “this building is not a museum,” says Dr. Stefan Schmitz, Executive Director of the trust, even though the concrete structure may look like one at first glance. “Countries around the world deposit seeds from crop plants here as a safety backup.” So far, 1.2 million varieties are stored at the Seed Vault, and their original copies are accessible for use. “Which, facing climate change and the loss of biodiversity, is a ‘life insurance’ for global food security,” Schmitz says.

The project is not made up solely of the Seed Vault in Norway, which is something like a backup copy of all the seeds known to humanity. Rather, it is an invisible network of more than 100 regional gene banks – all connected to the headquarters – that extends over the



Organic meets high tech

Natural cosmetics, an eco-niche? That is a thing of the past. Now, natural cosmetics means plant-based ingredients, scientific innovations and high growth rates. But is plant-based also the same as organic? And how can sustainability be achieved?



PHOTO: SEZENTYNSKE, ILDIKO KIEBURG-DIEHL & FABIANE HOOK; GETTY IMAGES / AF STUDIO; ISTOCK (COLIBRI, BORSINI, MIGUEL TAMAYO DIAZ); SHUTTERSTOCK (VICTOR JOSAN, MIHAI STOCK, ARTHEAD); MONTAGE: MICHAEL STACHATMANN

Nature is making its way into millions of bathrooms in a cream jar. More and more consumers consider a sustainable lifestyle important and are also paying closer attention to their skin care in this regard. According to Statista, one of Germany's leading statistics portals, about two-thirds of women questioned worldwide prefer natural ingredients. Half of those who responded think it is important that these ingredients drawn from nature are also vegan. Sustainable care products have developed into an engine for growth. "The market for natural and organic cosmetics is growing almost twice as fast as the cosmetics market overall," the Statista dossier on natural cosmetics says. And there is no end to the boom in sight. On the contrary, with rising environmental awareness, there is also huge growth in demand. Companies are responding: On the shelves, organic and natural cosmetics are arranged alongside clean beauty products and creams that advertise themselves with vegan ingredients.

Guaranteed natural?

However, the question of which cosmetics are really natural is far from simple. The problem is that terms such as near-natural and green cosmetics are not protected by law and, in some cases, are used very randomly. If you prefer ingredients that are of natural origin, you ought to be guided by seals of quality and certifications. Sea waves, leaves and a sun – these were the symbols used in the world's first verified natural cosmetics seal. It was developed in 1997 by natural cosmetics manufacturers in Germany, but could not succeed in establishing itself internationally. The most widespread certification system today is the COSMOS standard, created by an association of five European organizations. In Europe and South America, the seal of the international non-profit organization NATRUE is also represented, and in North America there is a seal awarded by the Natural Products Association. To sum up, it can be said that only with certified natural cosmetics is there a definition of what is considered natural.

All ingredients must have been made on a plant-based or inorganic-mineral foundation, and they can – although many users do not know this – also be of animal origin. However, this does not mean that cosmetics from nature are necessarily organic. That scope has its own certificates. There, up to 100 percent of the ingredients have to come from a controlled organic cultivation process, and additives like colorings or fragrances must have been produced in an environmentally and resource-friendly manner.

Whereas certified natural or organic cosmetics define exactly what ingredients may be contained, clean beauty approaches things from the other direction: Here, it is all about what is not included. Clean beauty manufacturers often leave out ingredients that have attracted criticism, but they do use both natural and synthetic raw materials ▶



Pomegranate oil and clay are common ingredients in natural cosmetics.

Everything can be used

Rambu-what? Largely unknown in the Western world, the evergreen rambutan tree has many fans in Asia – its fruit is rich in antioxidants and tastes good. By-products from the tree can also be used sustainably and effectively in cosmetics, as the organically certified BASF Rambutan Program demonstrates.

1 Leaves: An extract from the leaves helps to rejuvenate mature skin. Nephoria™ encourages the formation of collagens, among other things. The result of application tests shows improved skin elasticity and fewer wrinkles.

2 Shell: Valuable cosmetic ingredients can also be extracted from the spiky fruit shell. Nephhydrat™ supports optimal functioning of the skin barrier and measurably increases skin moisture.

3 Seeds: Rambutan seeds and fruit are well-known for their effectiveness as destroyers of fat. This can be used for protecting the scalp. Rambuvital™ reduces sebum oxidation and can help with hair loss. The seed extract improves the vitality of hair follicles.

4 The rind contains various compounds with antioxidant properties and is suited for use as an anti-aging ingredient.

PHOTO: SEFENTY8NE/ILDIKÓ KIEBURG-DIEHL & TARANÉ HOOCK; ILLUSTRATION: JÖRG BLOCK

in their products. The widely used claim “Free from ...” can mean many things. For example, one manufacturer will avoid silicones and parabens, another lactose or gluten. Mineral oils and synthetic fragrances are also often taboo.

Michelle Wong, a qualified chemist and beauty blogger from Australia, is troubled by the fact that clean beauty still lacks clear standards and that there is a lot of superficial knowledge in circulation. “It is often overlooked that many ingredients are perfectly safe to use in defined

quantities and that any ingredient can be harmful when used to excess,” says Wong, who conducts scientifically based examinations of beauty myths on the internet.

Dedicated clean beauty and natural cosmetics manufacturers agree that there is no place for microplastics in cosmetics – and especially not in the environment. The term microplastics covers solid, insoluble synthetic plastics with a diameter of less than 5 millimeters. In E.U. countries such as Sweden, France and Italy, plastic

microbeads used for exfoliation and cleansing are already forbidden. Often, the criticism goes further and includes soluble polymers – which, although they are not plastic, also do not decompose in the environment. Manufacturers are increasingly offering alternatives. These include the biopolymer Hydagen® Clean from BASF. It has an immediate cooling effect, which makes it well suited for eye pads intended to ease swelling. Like all BASF biopolymers, Hydagen Clean is biodegradable and comes entirely from renewable raw materials. It is extracted from the tuber of the konjac plant, which is indigenous to southwestern China.

Proven techniques

Humans have always drawn from nature for skin care. In Korea, ingredients from roots, seeds and blossoms have been used for centuries in elaborate beauty rituals. This is a trend that is now ▶

Terms such as near-natural and green cosmetics are not protected by law.

Paper from sugarcane, soap bars, natural oils from olives, or parts of the aloe vera plant – with sustainable cosmetics it is all about packaging and ingredients.

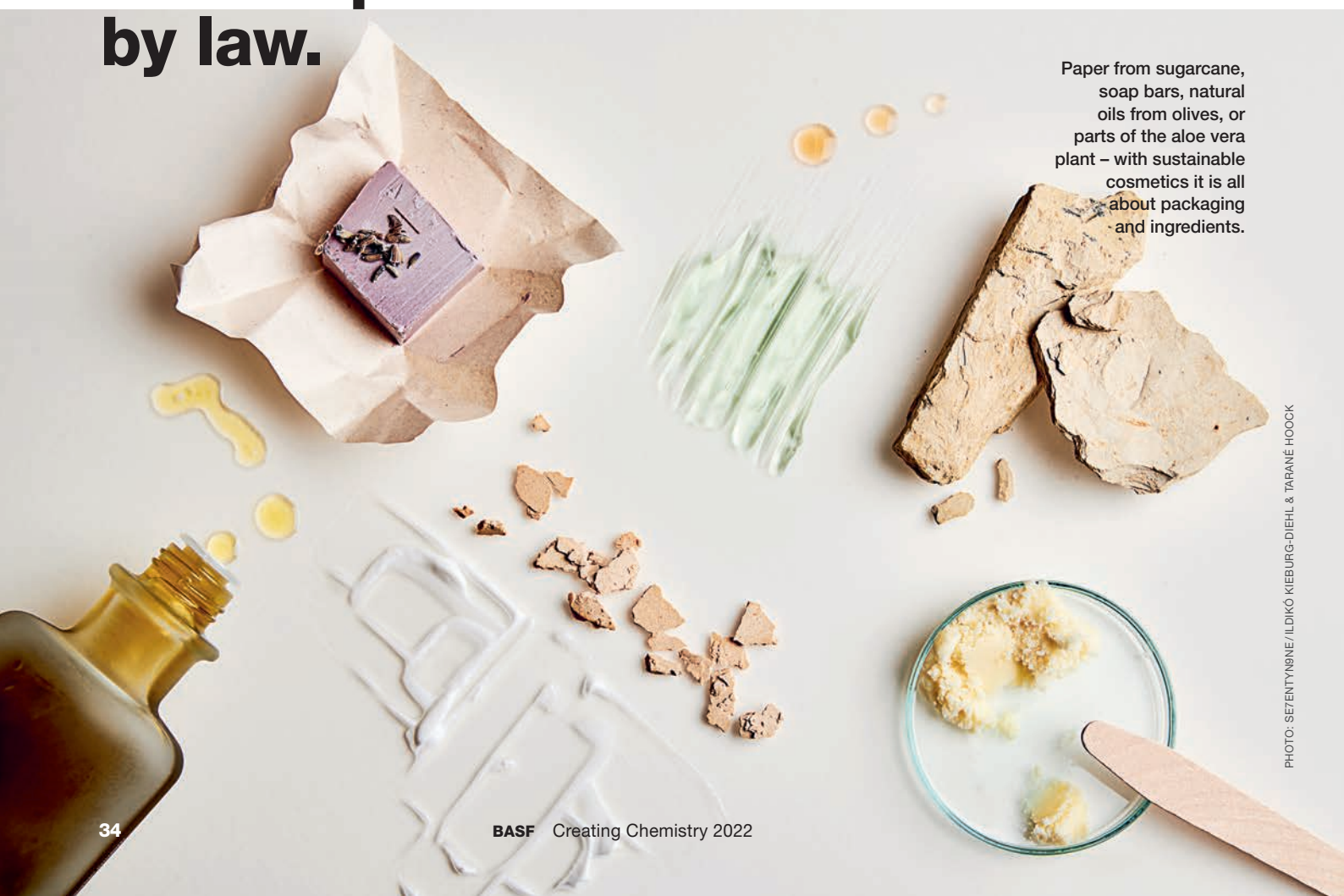


PHOTO: SEZENTYNSNE/ILDIKÓ KIEBURG-DIEHL & TARANÉ HOOK

What holds us together

Our largest and heaviest organ performs vital functions, yet is often underestimated. Here we show what this border guard between our inside and outside does for us.

Protective shield

With its hard skin, the **epidermis** protects against injuries caused by pressure and friction. It also protects a human being against drying out: Without it, our body would lose liters of water every day through evaporation.



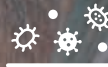
Air conditioning

One meter of the thinnest blood vessels and 100 **sweat glands** on one square centimeter of skin: these are the tools used especially by the **dermis** to keep our body temperature constant.



Feeler

Human skin contains approximately 640,000 **receptors** in total. These enable us to feel pain, pressure, cold and warmth, with most sensory functions based in the **dermis**.

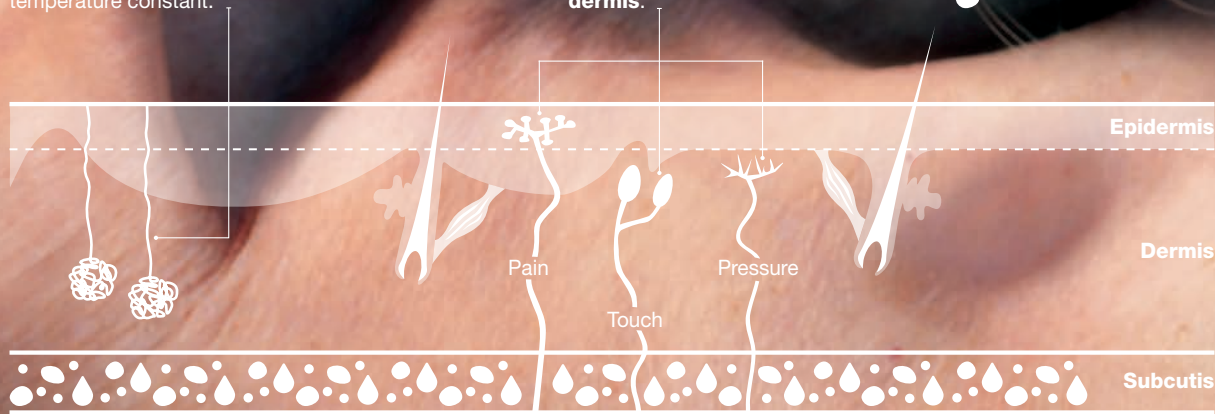


Immune system branch office

With its slightly acidic pH value between 4.7 and 5.75, the **epidermis** makes it hard for pathogens to penetrate into the body. If that barrier is still crossed, special cells gather up uninvited guests and transport them away.

Storage facility

One-quarter of the water stored in the whole body is held, along with fat, in the **subcutis**.



becoming known worldwide by the name K-Beauty. One of its representatives is the Korean cosmetics manufacturer Whamisa, which relies on certified natural cosmetics combined with innovative formulations. In his search for more sustainability in the cosmetics sector, Whamisa CEO Ryan Park rediscovered an ancient method: fermentation, the microbial or enzymatic conversion of organic substances into acids, gases or alcohol. "Fermentation is the cycle of life – it is a really attractive method where you do not have to throw anything away," says Park, who is also head of research at Whamisa. "Harmful bacteria are killed off during the fermentation process, and nutrients that are beneficial for the skin, such as vitamins and minerals, are created at the same time."

Natural ingredients are especially appealing to consumers in China. In 2020, sales in the natural and organic cosmetics sector there stood at about \$2 billion. This places China ahead of North America, which had sales of around \$1.3 billion. Next year, China could even surpass the \$3 billion barrier.

Naturally effective

The growing worldwide demand for natural cosmetics and body care has become one of the most important drivers of innovation for the sector – global market forecasts from Premium Beauty Media, for example, predict an average annual growth rate of 5.2 percent to \$54.5 billion in sales by 2027. This is also clear to see at BASF Care Creations®. "Our goal is to create formulations that are based on naturally obtained ingredients without any loss in performance," says Dr. Philippe Moussou, who is in charge of global research and development projects for cosmetic active ingredients at BASF. These include highly effective peptides as a natural weapon in the battle against aging skin. These small protein elements can make the skin more resistant and stronger, and even ease silent inflammation that smolders unnoticed in many people's bodies for a long time.

Moussou and his team used artificial intelligence to find out which of the millions and millions of possible peptide



Ancient beauty secrets

Care cosmetics from nature are as old as humanity. One story that has been handed down is the beauty ritual of the Egyptian Queen Cleopatra, who is said to have bathed in donkey milk more than 2,000 years ago. But there are other old recipes that are still fascinating today.



The scent of the rose doesn't just seduce in CHANEL's N°5 perfume: Rose oil contains tannins and nurturing lipids that can reduce wrinkles. In Syria, the scented *Rosa damascena* was hence processed by machine from as early as the mid-17th century.



Beauty of the jungle Indigenous peoples in the Amazon rainforest have been using clay as a face mask for generations. It is rich in minerals and trace elements such as silica. These ingredients keep the skin elastic and firm.



Aloe vera is also known as gift from Venus. The mildly antibacterial and nourishing effect of its sap has been a hit for thousands of years – even Alexander the Great is said to have carried the liliaceous plant with him on his campaigns.

Sustainability is not possible without the right packaging: The options range from glass jars with wooden lids to cork boxes and paper made from sugarcane.



“
Water-free cosmetics – this trend is here to stay.”

Michelle Wong
Beauty blogger

Australian beauty blogger Michelle Wong says confidently. However, something that is water-free can still be liquid: Cosmetics manufacturers like Whamisa use floral waters or extracts in place of plain water. “Thanks to this concentrated formula, daily skin care requires much smaller quantities of the product,” Ryan Park says.

Even though water-free cosmetics need less packaging, they cannot do without it entirely. After all, the contents have to stay clean and the compounds have to remain stable for a long time. To show responsibility for the environment, more and more manufacturers are using packaging with a high proportion of recycled material. Korean biocosmetics maker Whamisa uses, among other things, recyclable paper from sugarcane pulp and biodegradable oxo plastic tubes, as well as sealing caps made from recycled wood. The printing on the packaging is done with biodegradable soy ink.

Raw materials from nature, cultivated organically, water-free, and packed in recyclable or biodegradable materials – this all soothes consumers’ ecological conscience for a start. However, keeping track of things is not simple. “If you really want to use your cream naturally and sustainably, you ultimately have to pay close attention,” the blogger Michelle Wong says. ■

combinations are the most promising. This resulted in the new agent PeptAlde™ 4.0. Its raw material is organically grown rice. “Without artificial intelligence, it would have taken much longer to detect suitable peptides, or we would have depended on a chance discovery,” the scientist says. Both the development and testing processes are examples of sustainable thinking in the spirit of organic meets high tech. In the course of that work, BASF researchers together with French research institute CTIBiotech used bioprinting to

create skin models from a 3D printer. “In this way, we can test cosmetic ingredients much more effectively to see how active and compatible they are,” Moussou says.

Without water

They are hard to miss on the shelves and in advertisements: body care and facial cleansing products or shampoos sold as solids requiring little packaging. Water-free cosmetics are a resource-friendly, natural cosmetics trend with great potential for the future. “This trend is here to stay,” the

PHOTO: MICHELLE WONG

Secret cleaning agents

We think we know how to get our laundry clean – but what about biogas, the air, or the sea? That means a lot of work for cleaning agents such as amines, enzymes, nanoparticles or robots. We demonstrate how such a big cleanup works.

Stain removers

BASF Enzymes work as biocatalysts to control the metabolism in living organisms and break down fats, proteins and carbohydrates, among other things. However, they are also essential ingredients in detergents and remove stubborn stains like blood, cocoa, egg and grass in the washing machine. Just the smallest quantities are enough to remove stains highly effectively at low water temperatures. This reduces energy consumption and, consequently, CO₂ emissions in every washing cycle. BASF has many years of experience and expertise in detergents and cleaners and offers an efficient, sustainable product portfolio. The new Cellulase Lavery® C Bright 100 L, in conjunction with other ingredients, prevents textiles from turning gray.

 bit.ly/stain-removers

Washing machines for gas

BASF Around 50 years ago, the company invented the high-performance washing process for synthetic and natural gases. For our natural gas and biogas heating at home, for example, to work as well as possible, constituent parts of the gas like carbon dioxide and hydrogen sulfide have to be either reduced or completely washed out. One of the main washing agents for this is amines – organic nitrogen compounds. The washing process is based on a simple chemical principle: The BASF gas cleaning agents react with the acidic gas components that need to be removed in an acid-base reaction. The unwanted compounds are separated by the washing agent. Unlike in the home, however, this washing agent is processed and reused.

 oase.basf.com




Clean light

Canada During the coronavirus pandemic, the Canadian company Monos expanded its portfolio and now offers not just hard-shell cases and clothing but also cleaning wands with ultraviolet UVC light. According to the manufacturer, the CleanPod's special LEDs




kill up to 99.9 percent of germs on surfaces using a high-intensity wavelength of 265 to 275 nanometers. This can be used to disinfect objects such as tables, switches, handrails or cellphones.

 [monos.com](https://www.monos.com)



Repelling dirt

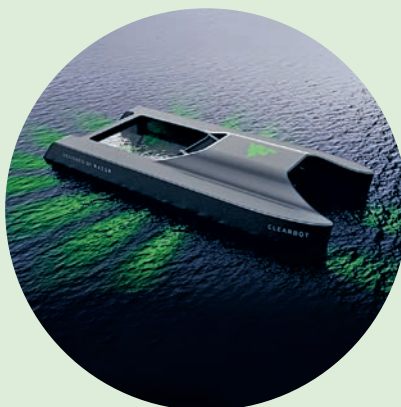
Germany Just a tiny fingerprint on a plug connection can be enough to cause a holdup in data transmission via fiber-optic cabling. The specialists at Rosenberger OSI in Augsburg hope their PreCONNECT® Lotus will come to the rescue. They are copying from nature: The fiber ends they have developed are based on the lotus effect. On the lotus plant, fine wax tubules reduce the contact surfaces on the leaf to a tiny area and cause foreign matter like dirt to simply drip off. PreCONNECT Lotus has water and oil-repellent nanocoatings that completely clean themselves and ensure faultless connections.


 [osi.rosenberger.com](https://www.osi.rosenberger.com)



Intelligent sea cleaner

China They have already cleaned up off the coasts of Bali, Indonesia and Hong Kong, China. Clearbots, which use artificial intelligence to identify waste in the water, gather it up and collect data on it. The solar-powered cleaners, developed by mechanical engineering students at the University of Hong Kong, perform their cleaning work autonomously. When their batteries are empty, they move automatically to the dock, where they are recharged. Each robot is able to collect up to one metric ton of waste per day from the water. The waste containers were initially emptied manually. From this year, the Clearbots will be able to dispose of their waste hydraulically and completely independently.



 [clearbot.org](https://www.clearbot.org)

Towering up against smog

Netherlands Purifying smog into clean air – this is the goal of the 7-meter-tall world's first Smog Free Tower, installed by the Dutch designer Daan Roosegaarde in Rotterdam, Netherlands, in 2015. The hexagonal tower, covered with slats, cleans some 30,000 cubic meters of air per hour. The Smog Free Tower works electrostatically. It disperses positively charged particles into the air, and the smog micro-particles attach themselves to them. These microparticles are sucked by a ventilator into the interior of the tower, where

they combine with negatively charged particles. The structure then blows the clean air back out into the open, where the aim is to create a smog-free zone. The patented technology manages without a filter using positive ionization, and only has to be cleaned once a year. There is a low energy consumption needed to clean the air – the tower uses less power than, for example, a kettle. This huge design installation is now producing fresh air not only in the Netherlands, but also in China, South Korea, Mexico and Poland.

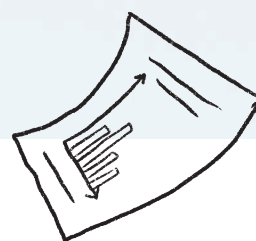


 bit.ly/smog-free-project

Technology & society



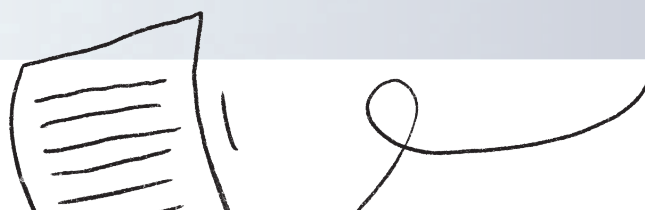
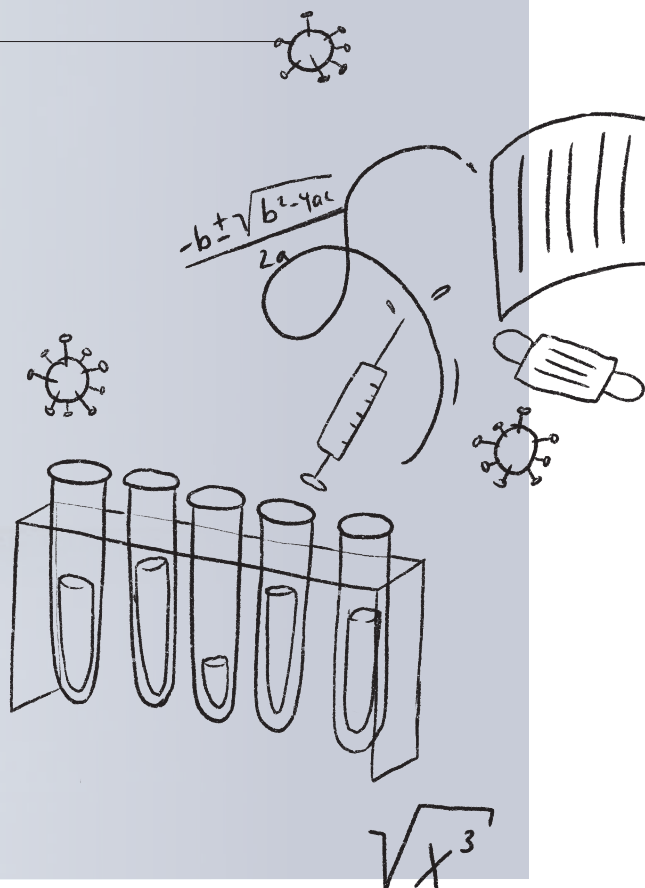
PHOTO: GETTY IMAGES / SANJERI; ILLUSTRATIONS: ASCS / CLARA PHILIPPZIG



What do we know?

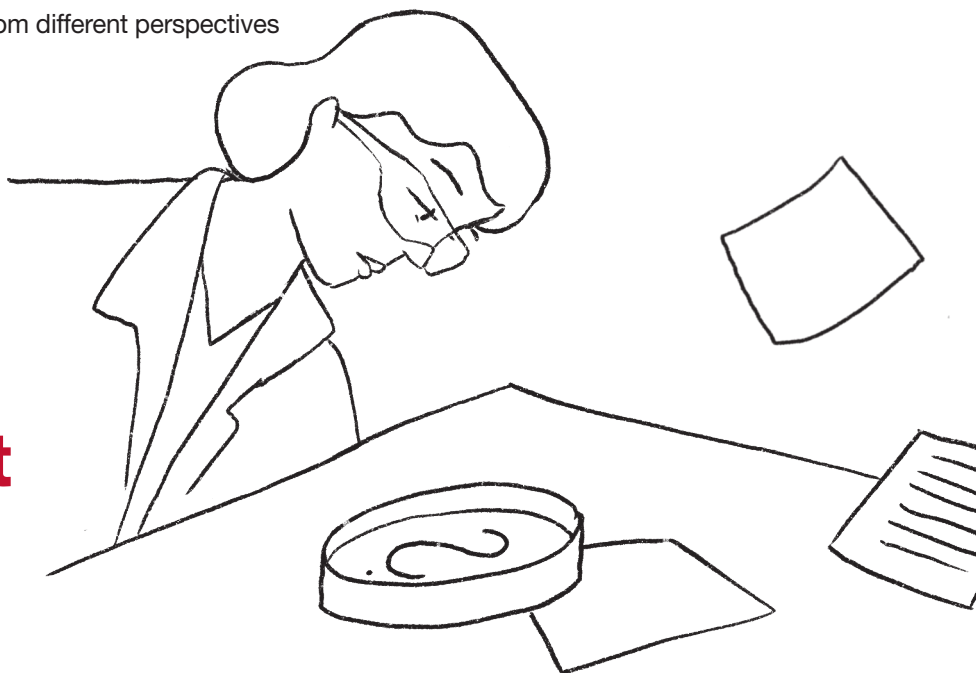
Informing ourselves sufficiently to make the right decisions is often difficult, particularly when it comes to complex issues. Who can we believe and trust? Creating Chemistry asked several experts about how we gather knowledge when much is at stake.

Covid-19 has revealed how unprepared we were for a global pandemic. It also showed how unprepared most of us are to deal with the scientific discovery of truth happening live before our eyes. Scientists have disagreed over everything from where the virus comes from to how dangerous it is and how to tackle it – leaving many bewildered and distrustful. It has shown that a healthy society needs citizens who know how to obtain balanced information and form their own judgements. A science journalist, a disinformation expert and a philosopher weighed in for Creating Chemistry. They noted that the general public does not realize that science is sometimes genuinely uncertain and disputed; that conspiracy theories are often a cry of protest from a minority who feel unheard and powerless; and that, for nearly everyone, trust is crucial for acquiring knowledge. A BASF scientist closes with reflections on the ongoing European battle over acceptance, or not, of genetically engineered crops. Transparency and communication are still the keys to good public decision-making, he says, knowing that this is far easier to say than to do.



The science journalist

Science is not always about certainty



Creating Chemistry: Does the public have a good grasp of how science works?

Volker Stollorz: The public is not monolithic: there are four subtypes. Sciencephiles, about 30 percent of the population, think science is great. Then there are Critically Interested, about 15 percent, who are positive toward and interested in science, but also sometimes skeptical. Another 40 percent are Passive Supporters, only moderately interested: they get their science from the mainstream media. The final 15 percent, the Disengaged, are not interested, and often distrust science and scientists.

How should science communicators address these different groups?

You need to think about which public you are addressing and ask yourself what information they may need or what concerns they may have. Listening to what people really want to know is the best way to communicate science.

In which ways has the pandemic affected science communication?

In early 2020, the pandemic was new to almost everyone, so there was real epistemic uncertainty. Normally, science knows what is going on. Scientists say: "We found A and that led us to B, case closed." But this was not happening, and that was difficult for the public to digest. They saw that science is not always about certainty, but about finding new knowledge in uncertain times.

Sometimes even science doesn't know what is going on. This was novel even for science journalists. So, there was a legitimate debate about the dangers of Covid – even scientists didn't know.

How do you get the right balance between presenting the limits of current knowledge and speculative ideas?

Science journalists have a different task from, say, political journalists. The job of political journalists is to present debate: Party A says this, Party B says that's rubbish – and vice versa. But science and science journalism are about having solid evidence to make a case. In times of great uncertainty, it is best to admit that. Don't say you know what you're talking about when you don't. Nonetheless, science reporting should show where expert thinking is headed. My general rule is: the stronger the scientific consensus, the more one can simplify, but the more epistemic uncertainty there is, the more you have to be on the lookout for the domain-specific expertise at the heart of a problem.

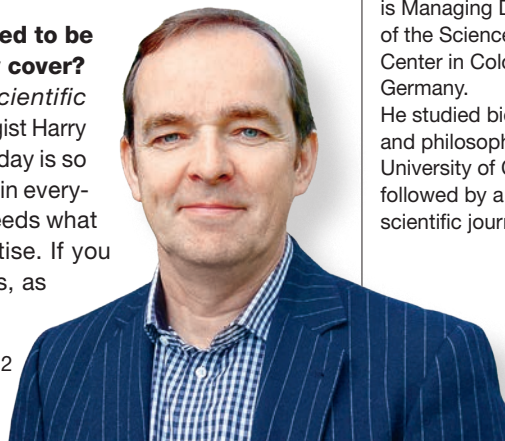
Do science journalists need to be experts in the topics they cover?

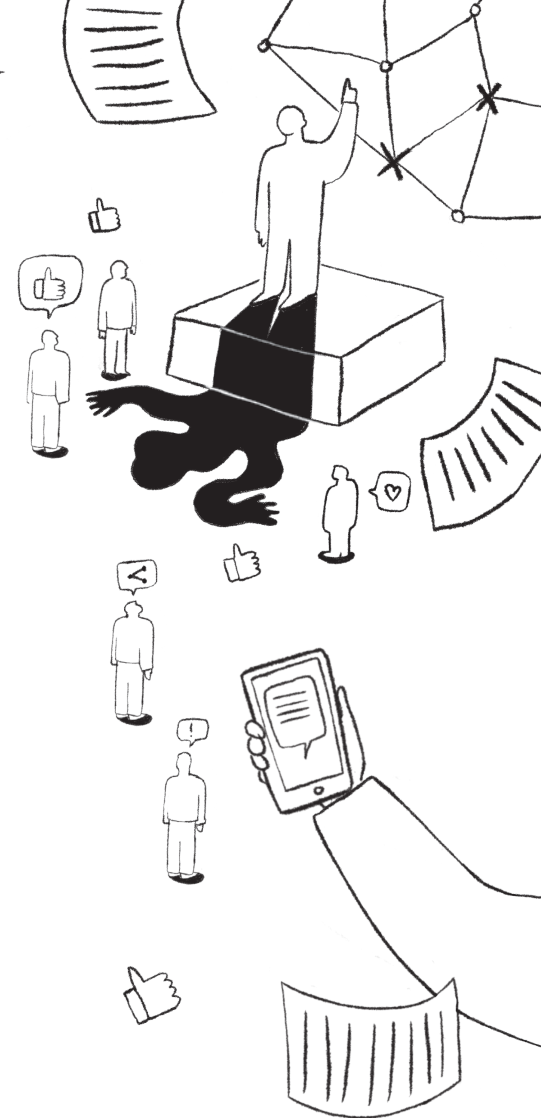
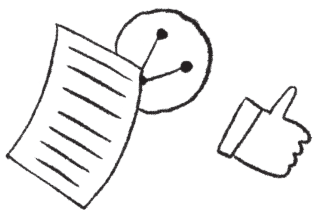
In his book *Are We All Scientific Experts Now?* British sociologist Harry Collins notes that science today is so large, nobody can be expert in everything. As a journalist, one needs what he calls interactional expertise. If you talk to thousands of experts, as

a science journalist does over the years, you learn how to identify who is an expert. I don't have the same knowledge as the expert, but I can feel when he or she is overpromising or doing public relations – or is an honest broker of facts. So, in case of doubt, good science journalists double-check with more than a few scientific experts to get a feeling of where the field stands on a certain question and what is the spectrum of legitimate opinions.

Volker Stollorz

is Managing Director of the Science Media Center in Cologne, Germany. He studied biology and philosophy at the University of Cologne, followed by a career in scientific journalism.





The disinformation expert

Conspiracy theories cannot just be dismissed

Creating Chemistry: What are conspiracy theories – is there an accepted definition?

Professor Thaiane Oliveira: Conspiracy theories attempt to explain complex social phenomena in narratives. They criticize society and authorities, denouncing what they see as society's ills. Traditionally found on the fringes of society, today they can also come from political leaders and the mainstream.

Why do people accept conspiracy theories and then hold on to them?

Frustration and resentment are key. Conspiracy theorists tend to be those who feel that they are not being heard; that their demands are not being met. They believe some authorities have become corrupt and self-serving and would like this to be corrected and purified. However, conspiracy theorists are not otherwise homogeneous, nor do they swallow every idea that comes along. Communications with like-minded people reinforce their beliefs, but they are not closed to new information.

What role does social media play in spreading conspiracy theories?

Digital social networks provide a meeting place for dissenting voices from society that share common feelings about complex social phenomena. Platform policies based on freedom of expression and algorithmically mediated personalized consumption have connived to amplify them.



How were conspiracy theories spread before social media?

There was always a way. People organized themselves socially, shared feelings and created explanations with neighbors, friends and family. Sometimes it was a joke among colleagues. But other times, so-called conspiracy theorists, or conspirators, needed underground meetings to overthrow authoritarian governments acting in their own interests. That's why we can't just dismiss conspiracy theories, because sometimes they bring up social problems and expose issues that go beyond a meaningless explanation.

What role do they play in politics more widely?

It can be tempting for the powerful to suppress criticism, especially in times of declining trust in those institutions, like science and media, that should underpin the democratic system. They take advantage of this disbelief and these feelings of resentment to present themselves as a necessary political change for the good of society. Once installed in power, they accuse political opponents of being conspiracy theorists or promoting lies. We live amid unprecedented technological change: biotech, artificial intelligence, facial recognition. Anxieties around these provide fertile ground for conspiracy theories that could be exploited for undemocratic purposes. We should not ignore this danger.

How can we protect ourselves against harmful conspiracy theories?

Dispute, challenge and skepticism are part of democracy. We need critics, and we need to accept that some criticisms will be wrong. Most conspiracy theorists argue that public institutions are not transparent enough. Institutions that are challenged by conspiracy theorists should see it as an opportunity to recognize their own responsibility. Civic participation, open debate and discussion are the keys to recovering public trust.

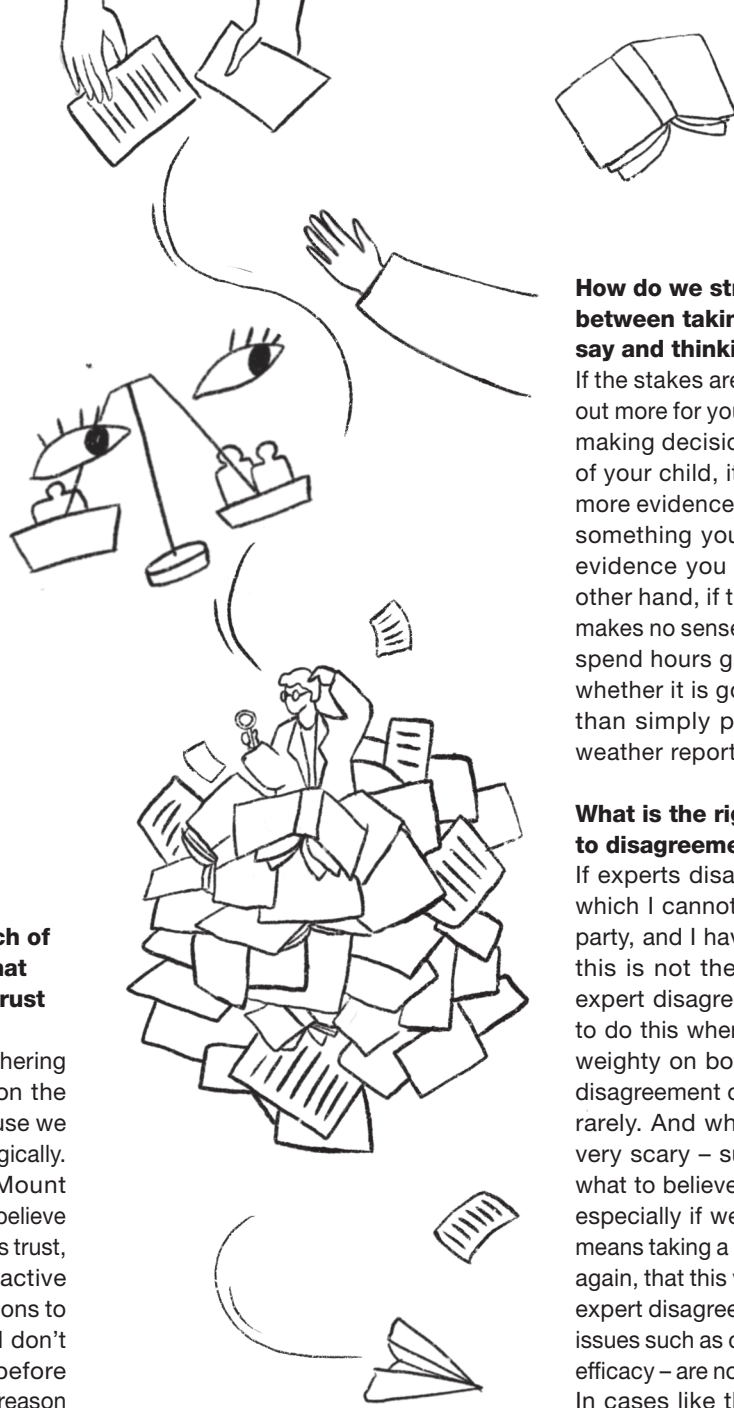
Thaiane Oliveira

is Professor of the Graduate Program in Communication at the Fluminense Federal University, Brazil. Her research focuses on disinformation about science.



The philosopher

The truth is out there waiting for us to find it



Creating Chemistry: Since much of what we know derives from what others tell us, what role does trust play?

Professor Mona Simion: In gathering knowledge, we rely very much on the testimony of others. That is because we are limited physically and psychologically. I cannot check the height of Mount Kilimanjaro in Tanzania myself, so I believe my geography teacher. This involves trust, but in a passive rather than an active manner. I don't need positive reasons to believe my geography teacher – I don't need to check her credentials before believing her, I just need to have no reason to believe she is untrustworthy.

What happens if our faith in experts breaks down?

Expert testimony is very weighty evidence. In an environment where there is a lot of distrust, however, we start to suspect experts are deceiving us. That is unhealthy because it means we can't take advantage of their expertise. It is also often irrational to rely more on our opinions than on expert testimony: Experts are more reliable than us because we, as a society, have invested resources in educating them. Dividing epistemic labor in this way makes us very good at gathering information.



Mona Simion

is Professor of Philosophy and Deputy Director of the COGITO Epistemology Research Centre at Glasgow University, Scotland. She is an expert in social epistemology.

How do we strike the right balance between taking on trust what others say and thinking for ourselves?

If the stakes are high, it is rational to find out more for yourself. For example, when making decisions that affect the health of your child, it is rational to search for more evidence. Expert evidence is then something you weigh alongside other evidence you gather yourself. On the other hand, if the stakes are not high, it makes no sense to do this – you wouldn't spend hours gathering evidence about whether it is going to rain today, rather than simply putting your trust in the weather report.

What is the right way to react to disagreement between experts?

If experts disagree, there are cases in which I cannot rationally believe either party, and I have to suspend belief. But this is not the case in the face of all expert disagreement. It is only rational to do this when the evidence is equally weighty on both sides. Serious expert disagreement of that type happens very rarely. And when it does happen, it is very scary – suddenly, we don't know what to believe any more and it is hard, especially if we need to act, because it means taking a risk. But the good news is, again, that this very rarely happens. Most expert disagreements that we see – over issues such as climate change, or vaccine efficacy – are not balanced in this manner: In cases like these, suspending belief is irrational.

What happens when something that we think we know turns out not to be true?

Truth is out there waiting for us to find it. We are fallible creatures and we do get it wrong once in a while. But that's fine. What is important is that we base our actions on the amount of information that we have available at the time. The fact that we have survived is evidence that we mostly get it right. For the most part, we are very reliable producers and receivers of knowledge. Sometimes we get it wrong, but these instances are quite reduced. The best we can do is follow our evidence as well as we can.

Viewpoint BASF

Constructive dialogue must acknowledge different beliefs

Humans have always been challenged by the complexity of nature. Confronted with different explanations, they look for the one they take to be true, guided either by gut feeling or by a person or institution they consider trustworthy. Even experts are not free from subjectivity. Everyone is influenced by their attitudes, values and individual life circumstances.

At BASF Agricultural Solutions, we have experienced this firsthand. Our products often provoke debate. The use of crop protection or molecular biology in plant breeding are polarizing topics. Take Amflora. In 2010, this genetically modified potato variety, developed as an optimized renewable raw material for the potato starch industry, was approved by the authorities for cultivation in Europe. We knew there could be consumer concerns, so we launched an extensive communication campaign with lectures, panel discussions and a dedicated website. Nevertheless, the criticism from non-governmental organizations and others was huge. Although the product had been exhaustively tested and approved in numerous scientific studies, we failed to convince the broader public of its safety and benefits. Pressure by environmental groups was massive and persistent so we stopped the project.

Today, we have a similar experience with CRISPR/Cas, a new method for modifying genetic information. The technology could be used in plant breeding

to develop specifically adapted varieties that can, for example, better withstand heat or drought as a result of climate change. But opponents of this technology fear the effects could be unpredictable, and some even reject modern breeding in principle.

When both sides of the argument claim to act in the spirit of sustainability, how can the public make up its mind? At the time of Amflora's approval, I was responsible for regulatory approval and frustrated that we failed to convince the public of our point of view. An open debate does not seem possible when people only allow the scientific information that confirms their preconceived opinions.

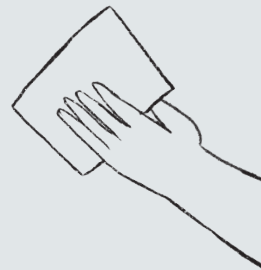
How can we find common ground to start a constructive dialogue?

To some extent it depends on the environment in which discussions take place. In a panel discussion with a large audience, people have their message to convey, and they stick to it. But in smaller groups, there is a chance to make people think differently about a product. You also get a better understanding of where their concerns come from. So, we are increasingly focusing on developing discussions with the public, and instead of an us-and-them approach, we ask how we can jointly define value for society.

When you've spent 20 years trying to explain a subject



and you still hear the same objections that you don't think are valid, it can definitely be frustrating. But I'm optimistic that solidified positions can change when people start looking at a topic from a completely different angle. The younger generation is very focused on addressing challenges like climate change. I think they will take a different, more open-minded position about technologies like genetic engineering in plant breeding that can be part of the solution. ■



Matthias Pohl

has a PhD in biology and is Head of Global Societal Outreach at BASF Agricultural Solutions, Limburgerhof, Germany.



The nature of color

Tree resin, bird droppings, earth or synthetic colorants: The origin of colors is varied, and so is their significance for our culture and everyday lives – and even our psyche. A brief excursion into the bright world of colors and paints

Ten years ago, David Kremer and the German artist Peter Lang were hiking in Iceland over glaciers, mosses and rocks. The two friends were hunting for the island's distinctive colors. They scratched and dug around in the earth, and in the end, they secured the mining rights to three new earth colors – Snaefellsjoekull Red, Heydalsvegur Yellow, and Brimisvellir Green – named for the sites on the island where they were discovered. “The nuances resemble French and Italian earths but still have something very special and beautiful about them,” Kremer enthuses.

David Kremer inherited his father's passion for pigments and now manages the business of Kremer Pigmente in Aichstetten, Germany – the company that his father established. The global market leader in historical pigments makes 250 of its total of

1,500 colors according to traditional recipes. Many of the pigment specialists' raw materials come from nature: eggshells, bird droppings, ochre from Burgundy, green earth from Verona and pigments from the gland secretion of the purple snail. Their customers include artists and restorers from all over the world. The Louvre in Paris and MoMA in New York buy from Kremer, but so do companies such as BASF.

Art conservators, in particular, need natural pigments. This is because the best way to recreate a painting that was produced with local pigments in Italian cities such as Florence or Venice is to go back to local pigments from the relevant region. But specific requests from artists can also be fulfilled. For example, if you wish to use iPhone gray for your painting or give it a touch of luxury with diamond powder, you can get it from Kremer.

The German artist Peter Lang created his paintings for the Northern Lights series using Icelandic Kremer pigments.

Kremer's view of the world of colors is determined by colorfulness, materiality and the production process. "To me, a true color is anything that is pure and cannot be created by remixing," Kremer says. One example of this is lapis lazuli. At a price of about €20,000 per kilogram of the highest-quality product, this deep blue semi-precious stone is the most expensive natural pigment. It is mined in only two countries. The best deep blue quality in the world is found in Afghanistan, but because of the political situation, it is hard to buy it. The stones that come from Chile are more pale.

A question of culture

Colors are a material and a commodity, but they are also loaded with many layers of meaning, impact and feeling. For example, in China, green is associated with the female principle of yin and serves as a symbol of long life and compassion. In Islamic culture, on the other hand, green is male, as the color of Muhammad. It denotes things like mental well-being and material prosperity. Europeans, meanwhile, associate green with growth and believe it is good against tension and stress – and so effective, in fact, that some health-insurance funds in Switzerland now support the treatment of burnout patients with green light waves.

A culture's location in terms of climate also has a bearing on how colors are perceived. If you see red when you are angry, you are probably not a Russian. In very cold countries, red – as the color of warmth – has mainly positive associations. In Russia, red means something valuable or beautiful, and the metaphor that translates literally as "red word" denotes a witty remark. In Arab culture, where scorching heat can become life-threatening, red represents something demonic. In China, it is the color of happiness, and many small children wear red clothes.

From mood to trend

When trend consultant Michell Lott from São Paulo, Brazil, is developing color trends, what matters to him is not so much cultural symbolism as current needs. As a color expert, he conducts worldwide research to absorb moods from

which he can create new color palettes. Currently, for example, one of these is for Suvinil, a BASF decorative paint brand for surfaces such as walls, furniture or floors, marketed in South America and selected African countries.

"Colors are energy. You absorb them when you enter a room," the interior design expert says. In the year of the coronavirus pandemic, its screaming flood of news, and worries about people's families and jobs, Lott encountered a need in society for calm and reassurance. This withdrawal into an inner world required colors that would not provide additional bursts of energy to unsettle people even more. He developed a color range containing subtly pigmented white tones with different degrees of saturation. In Lott's view, mineral coloring, bright green tones, and earth and brown pigments reflect the desire of people stressed by the pandemic to form a bond with nature.

Now, stronger dashes of color are again becoming mixed in with the calm tones in the color palette that Lott developed – some blue here, or candy orange there. For the color consultant, this expresses the desire to return ▶



“**To me, a true color is anything that is pure and cannot be created by remixing.**”

David Kremer
CEO, Kremer Pigmente



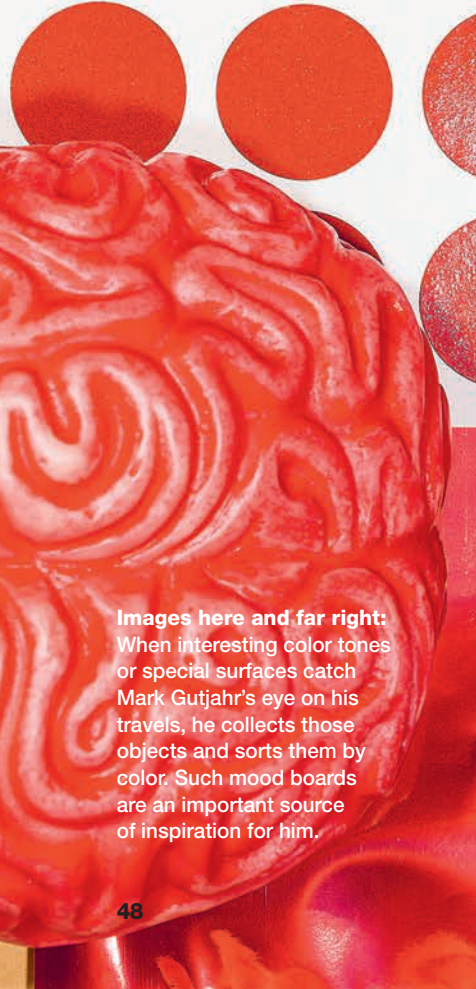
The hunt for new color pigments often involves digging. David Kremer uses this slate to make Côte d'Azur violet, which was commonly used in Italian painting.



Technology & society

“
The past
two decades
have been
the least
colorful.”

Mark Gutjahr
Head of Automotive Color Design,
EMEA, BASF Coatings



Images here and far right:
When interesting color tones or special surfaces catch Mark Gutjahr's eye on his travels, he collects those objects and sorts them by color. Such mood boards are an important source of inspiration for him.

to more vibrancy after long lockdowns. But these richer colors also represent technology and digitalization. Nevertheless, Lott is convinced that “the trend toward natural earth tones will continue for ten to fifteen years.”

Someone else who is following such long-term developments – or macrotrends, as they are known – is Mark Gutjahr, Head of Automotive Color Design, EMEA, at BASF's Coatings division.

Working with the global design team, he has developed a trend radar that observes, for example, how values in a society shift over the long term. Since the aim is to translate trends into colors for automobiles that match the spirit of their times, there is no room for short-term color trends that only last for a year, as they do in fashion. Vehicle colors have to remain current for more than one season. This is due partly to the development cycles and marketing activities of vehicle manufacturers and partly to their customers. Germans, for example,

drive their vehicles for around nine-and-a-half years on average. It takes two to three years to develop a vehicle paint and make it ready for series production. Gutjahr and his team are constantly working on their trend research, so that they are always able to develop and present new color nuances.

Desire for warmer hues

Gutjahr was already observing the trend toward warm color tone ranges in pre-coronavirus times. “These tones represent a desire for a more empathetic society, as well as the global phenomenon that people no longer want to organize their life plans exclusively according to the performance principle,” the BASF design chief says. The pandemic has further strengthened this trend.

Consequently, beige has become a new trend color in the latest color palettes for automobiles. Gray tones are becoming gentler and less metallic, and a mineral quartz gray is appearing with many

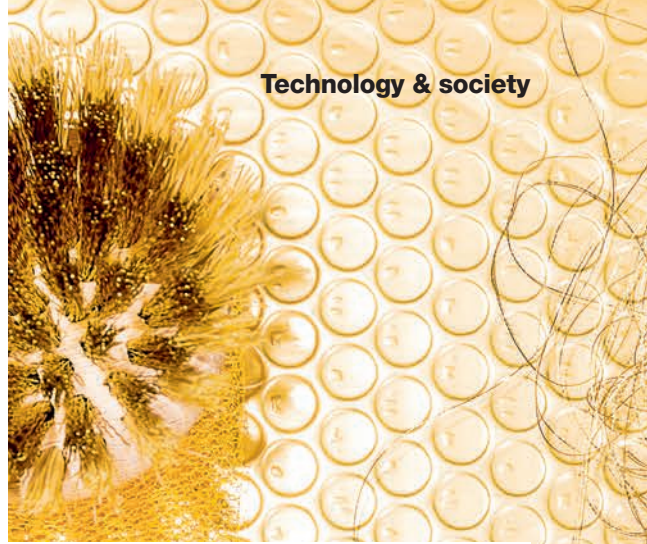
PHOTOS: CARSTEN BEHLER; BASF COATINGS



PHOTOS: CARSTEN BEHLER; GETTY IMAGES (SHAUN LEE PHOTO, JAY DICKMAN, OLIVIER SCHMIDT / 500PX, WESTENBÖT, FERNANDO TRABANCO, SIRACHAI ARUNRUGSITICHAI)

manufacturers. Warmer color tones are gradually infiltrating themselves among the harsh, bluish paints on the roads. With his 33-year-old Porsche in metallic nougat brown, Gutjahr is therefore very much in line with the trend. A Porsche color also currently inspires the design chief: frozen berry. This new, warm, gray-pink color tone shows that even sporty automobile types are not immune to the trend toward a new gentleness.

However, the roads are still dominated by different colors. White accounted for 26 percent of new registrations in the Europe, Middle East and Africa (EMEA) region in 2021. Gray ranked second on 23 percent, followed by black on 15 percent. The most popular colorful tone, on 14 percent, was blue, which manufacturers used in around 180 different color nuances. The proportion of bright colors is slowly increasing again in all vehicle segments. A quarter of all mid-range vehicles are painted in a chromatic shade. For larger vehicles, ▶



And what can they see?

Human beings can perceive between 100,000 and 1 million colors through three types of color receptors (sensitive to blue, green and red). But it gets even better. The animal kingdom has specialists in ultraviolet (UV) light and masters of spectral color vision – but also some that are color-blind. Here is a small selection.



Dogs and cats,

like most land mammals, possess only two different types of color receptors. They can see their surroundings only in shades of blue and yellow. However, their eyes are better at perceiving movement than those of human beings, and this is important for them as hunters.



Marine mammals

such as whales and seals have lost a color receptor in the course of evolution and, as far as is currently known, see the world only in black-and-white and shades of gray. The eye of a baleen whale can actually distinguish only between light and dark.



Mantis shrimps

perceive the basic colors of their surroundings extremely quickly with more than ten different color receptors. This saves the brain energy and time when the shrimp is identifying its potential prey.



Birds

are masters of color vision. In addition to red, green, and blue, they can see short-wave UV light. This enables them to better identify leaf structures, and that helps them to find their way in a forest.



Geckos

Nocturnal geckos use their three types of color receptors to see in weak light. This means their world is full of colors even at night. Most other vertebrates and human beings, on the other hand, are color-blind at night.



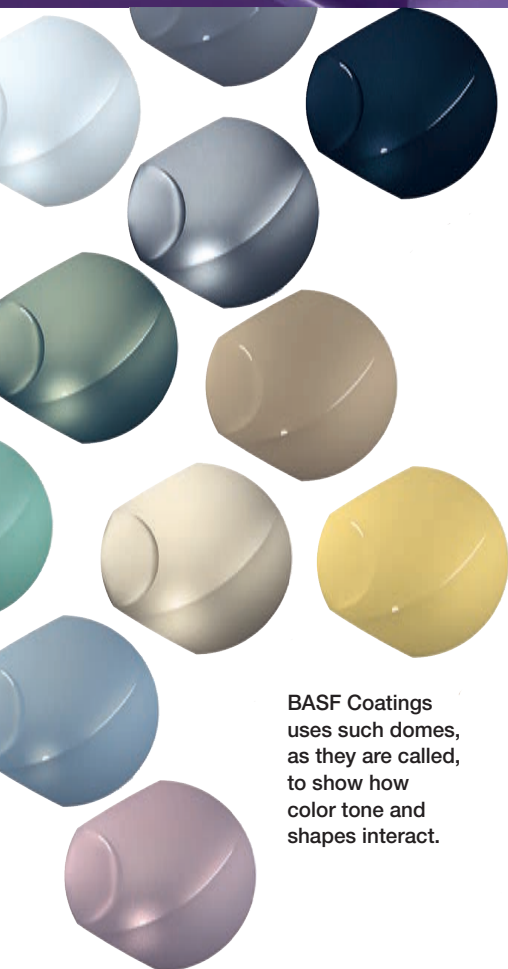
Butterflies

The color champion among butterflies is the hummingbird hawk-moth. It possesses 15 different color receptors – five alone for red light and several for various blue and green tones and UV light. They probably help it to find hidden flowers.

For drivers who show color courage: the color Parolis Purple, developed by BASF Coatings

There are 250,000 color recipes in the world just for car paint.

Source: BASF



BASF Coatings uses such domes, as they are called, to show how color tone and shapes interact.

the figure is as high as 30 percent – as it is for small cars, where color diversity is at its highest.

The courage in color choice that drivers demonstrated 30 years ago has now become a thing of the past. “The past two decades have been the least colorful,” Gutjahr says. The silver of the noughties gave way ten years ago to white, which is now the most popular vehicle color worldwide. White is considered to be clean, elegant, classy, timeless and classic – especially in China, where more than half of new vehicle registrations are white.

Unachievable nature

In theory, drivers can now choose from 250,000 colors. However, although so much is now possible, nature offers displays of color that are extremely hard to replicate artificially. The thrilling color appearance of the bird of paradise, whose plumage changes between orange-yellow and blue-green depending on how the light falls,

is missing from the standard repertoire of color designers and pigment miners. The bird owes its iridescence, which remains inimitable to this day, to its plumage, which is structured and arranged in a very distinctive way. Companies such as BASF are experimenting with new artificial carrier substances that are intended to catch the light so that it shimmers like the plumage of the bird of paradise.

While industry continues to work on new levels of perfection, Kremer carries on searching for the kinds of irregularity that only nature can offer. He is currently focusing on a specific tree resin – one that can be used to make a varnish that is less clean than those currently available. This is the object of desire for ambitious violin-makers, who are on the hunt for the best possible reproduction of the unique Stradivarius sound. To create that, the violin needs a varnish from naturally contaminated resins of the sort that Antonio Giacomo Stradivari found at the end of the 17th century. ■

Colors make history

Purple power

Purple, extracted drop by drop from the glands of a subspecies of the murex snail, remains one of the most expensive colorings in the world. In ancient Rome, the color became a status symbol: A strict dress code governed who was allowed to wear purple. Only in 1856 did the color of power become ordinary. The British chemist, William Henry Perkin, then aged 18, was experimenting when he accidentally discovered the first synthetic colorant, aniline purple.



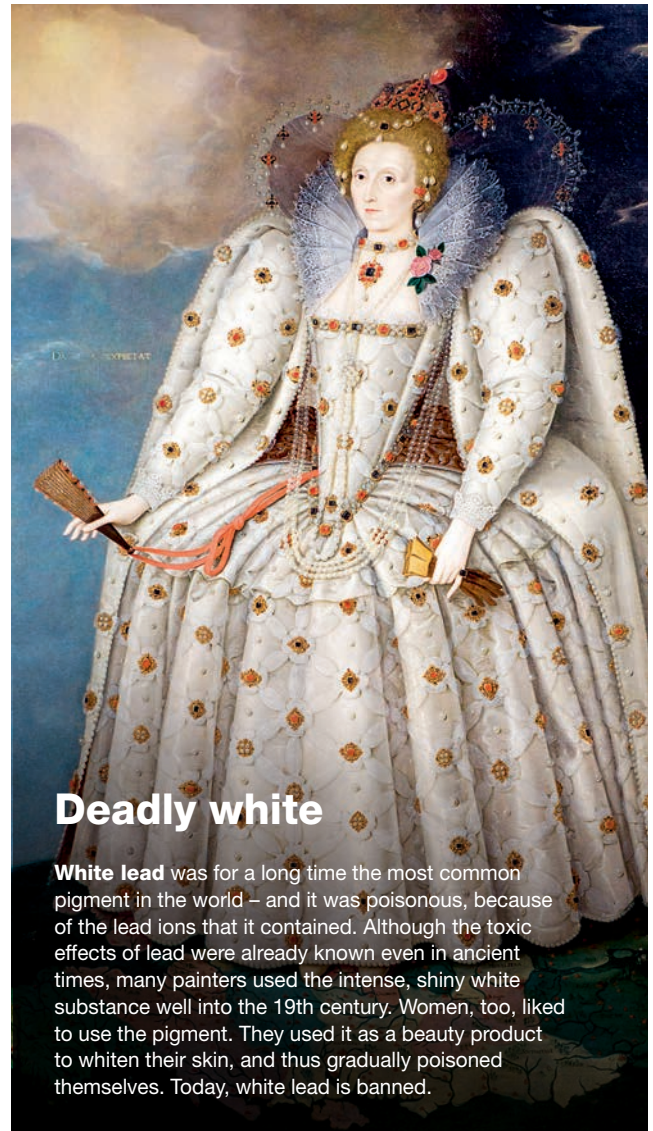
Medicine in blue

Methylene blue was produced artificially by the BASF chemist Heinrich Caro in 1876. The intense blue tone is still used to dye fibers and paper and is also a source of hope for medicine. Among other things, it is used in chemically modified form against Alzheimer's. Recently, the dye was also rediscovered as a substance to combat malaria.



Reddening world

Venetian silk, Roman cardinals' robes, and the cheeks of French ladies were all dyed **crimson**. That dye comes from the bodies of the female cochineal scale insect. The Spanish controlled a monopoly and sold the dye at such exorbitant prices that there were attempts to capture the insects, which had been imported by the Spanish colonial rulers.



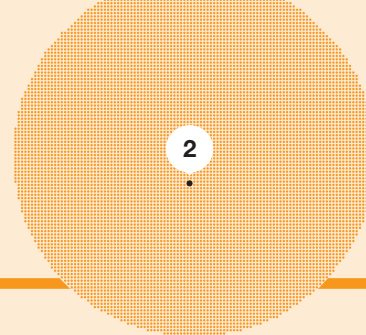
Deadly white

White lead was for a long time the most common pigment in the world – and it was poisonous, because of the lead ions that it contained. Although the toxic effects of lead were already known even in ancient times, many painters used the intense, shiny white substance well into the 19th century. Women, too, liked to use the pigment. They used it as a beauty product to whiten their skin, and thus gradually poisoned themselves. Today, white lead is banned.

Color of nothingness

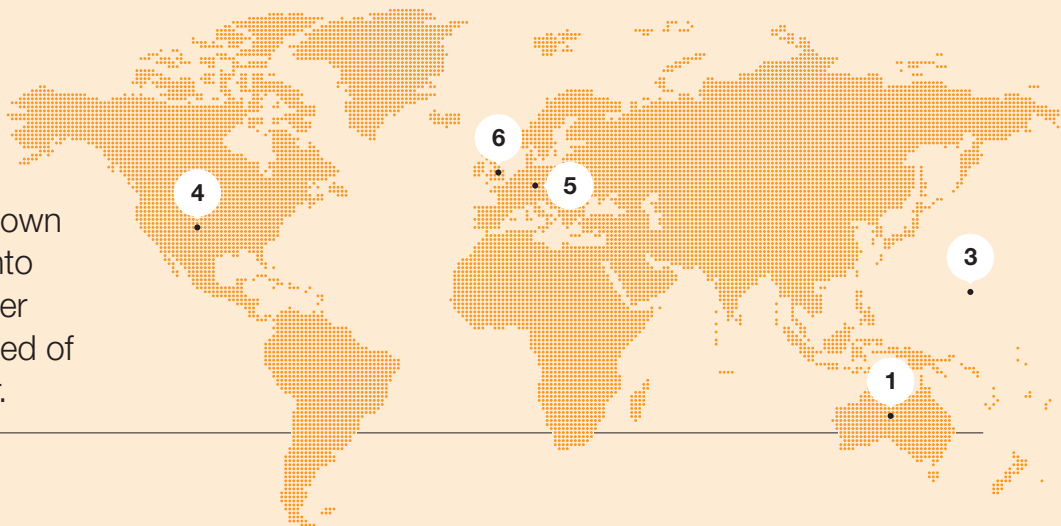
Vantablack was long considered to be the blackest black: it absorbs 99.965 percent of incoming light. If you look at it, you have a feeling that you are staring into nothingness. Employees at the Massachusetts Institute of Technology (MIT) in the United States say that they have increased this darkness even further. Their black, too, consists of many millions of tiny carbon nanotubes that are arranged standing alongside each other on a surface. In the narrow gaps, light is said to be absorbed to an even greater degree than with Vantablack – by 99.995 percent.





We will get there!

We take you off to Mars with Perseverance, dive down with you 11,000 meters into the depths, and fly together around the world at a speed of 2,000 kilometers per hour.



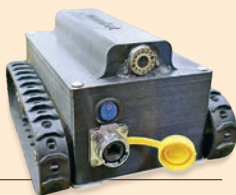
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Cave crawler

Australia More and more wombats are suffering from sarcoptic mange, which is similar to scabies in humans. To understand how this highly contagious skin disease is transmitted among marsupials, two years ago, Australian scientists sent a robot called WomBot through narrow tunnels into the animals' burrows. What it discovered was that the burrows offer ideal living conditions for the mites that trigger the mange. Researchers are now considering how the WomBot can help keep the mites in check.



bit.ly/wom-bot



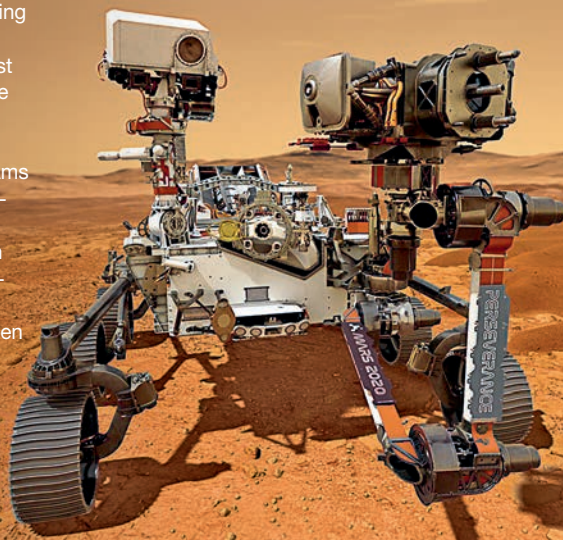
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Extraterrestrial

Mars Has there ever been life on Mars? This is what the Mars rover, Perseverance, aims to investigate. Scientists and engineers spent seven years developing and building the six-wheeled vehicle with its 2-meter-long robotic arm, at a cost of about €1.9 billion. In order to be able to move around on the red planet and collect rock samples, the rover – weighing 1,000 kilograms and about the size of a small car – requires energy. This comes in part from rechargeable lithium-ion batteries containing nickel-cobalt-aluminum oxide cathode active materials from BASF that have been adapted specially for this space voyage. At 472 million kilometers, the NASA Mars mission is the longest distance that a BASF product has ever traveled.



bit.ly/go2mars2020

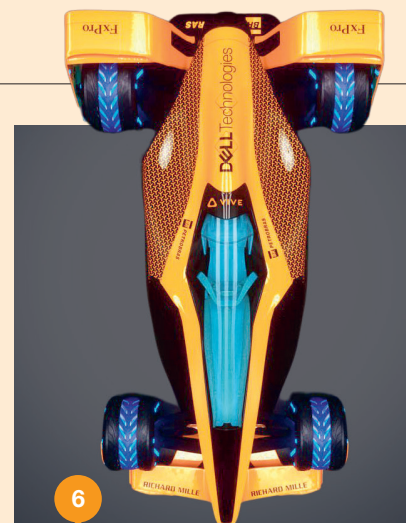




3 Deepest depths

Mariana Trench In 2019, the U.S. adventurer Victor Vescovo set a new record for the deepest dive – at 10,928 meters – in the Mariana Trench in the Pacific. To achieve this, his manned special submarine, the Limiting Factor, had to withstand an extreme pressure of around 1,000 bar. For comparison, an automobile tire has a pressure of around 2.5 bar. The submarine was prevented from bursting by its spherical hull, consisting of a 9-centimeter-thick titanium wall. “I don’t trust a lot of things in life,” Vescovo stressed. “But I do trust titanium, math, and finite element analysis to figure out whether or not materials can survive these extraordinary pressures.”

bit.ly/vescovo-talk



6 E-mode extreme

England “Fast, predatory and instinctive” is how the British racing team McLaren wants its Formula 1 racing cars to be in 2050. The idea is that they will be fully electric, inductively charged while on the move, and put a speed of 500 kilometers per hour on the clock with the help of moving aerodynamic parts. The co-pilot function is to be performed by artificial intelligence (AI), which is connected to the driver through the helmet and sensors on the race suit. The AI will learn from the driver’s preferences and frame of mind and deliver both important information and the appropriate strategy for the race.

bit.ly/futuregrandprix

4 Supersonic

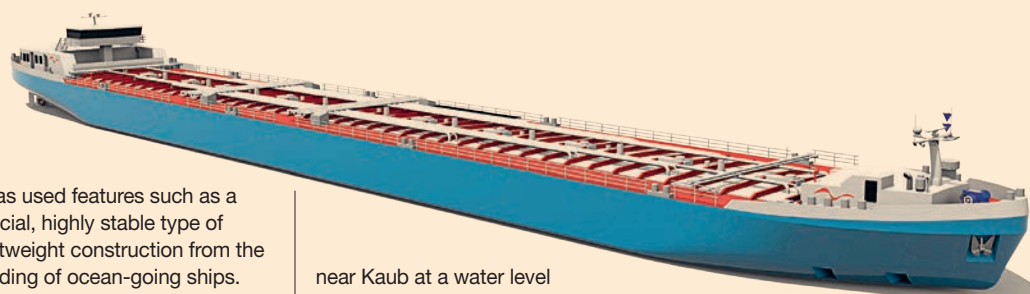
United States The new carbon-neutral supersonic jet Overture is expected to take just three-and-a-half hours to fly from New York to London. With a top speed of more than 2,000 kilometers per hour, this aircraft from the manufacturer Boom Supersonic in Denver, United States, is about one-and-a-half times faster than sound. U.S.-based United Airlines has already commissioned 15 aircraft. Production is set to start in 2025. Four years later, the first passengers are due to be able to take their seats on this low-noise jet – more than two decades after the last flight by Concorde.



boomsupersonic.com

5 Sailing through the shallows

Germany A very special mode of transport – the new BASF tanker – is due to be launched before the end of this year. It will be one of the largest inland vessels on the river Rhine. Its shallow draft ensures that raw materials make their way to the BASF site at Ludwigshafen even at low water levels. The company has worked with partners to develop this innovative type of vessel.



It has used features such as a special, highly stable type of lightweight construction from the building of ocean-going ships. The tanker will still be able to pass the critical point in the Rhine

near Kaub at a water level of 30 centimeters with a cargo of 650 tons.


Feeding young minds

A child can't learn well on an empty stomach. Food4Education in Kenya shows that investment in nutrition pays off.

As dawn breaks over Ruiru, a small town on the northeastern outskirts of Nairobi, Kenya's capital, Lucy Wangui is getting ready to head home. The 45-year-old mother of three and her colleagues have spent the night at the Ruiru Primary School cooking hot lunches that will be served to thousands of schoolchildren at schools across the town as part of a groundbreaking school feeding program.

The program is run by Food4Education, a Nairobi-based non-profit that provides subsidized meals prepared in kitchens at three different schools and delivered to 33,000 students in total. Wangui believes it is a godsend. "The assurance that kids will get at least one warm meal is a big relief for parents struggling to make ends meet," she says. The food at Ruiru Primary School is cooked in a brightly painted kitchen. Just a few meters away is a modern building housing a gleaming steam kitchen – the next step in the evolution of Food4Education.

It is a far cry from 2011, when founder Wawira Njiru, then a 20-year-old student at the University of South Australia studying nutrition and food science, decided to raise funds for school feeding. "I grew up in ►



Celestine Nawire attends to a vat of rice in one of nine cookers, each with a capacity of 600 kilograms.





Food4Education founder Wawira Njiru inside the new steam kitchen.



“
Nothing in the economy gives a better rate of return than feeding kids.”

Wawira Njiru
UN Person of the Year 2021

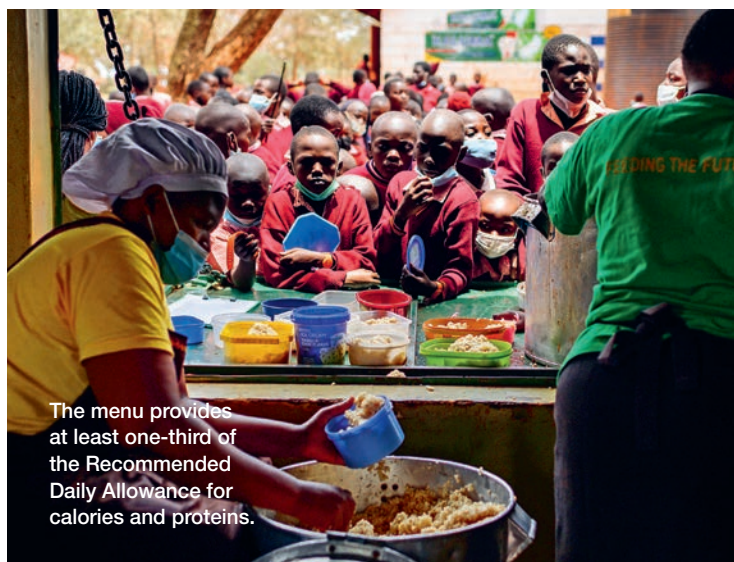
PHOTOS: GORDWIN ODHAMBO

73 million of the most vulnerable primary school students globally lack access to school meals.

Source: UN World Food Programme 2020



Workers sort and weigh grain and other foodstuffs, many supplied by local farmers.



The menu provides at least one-third of the Recommended Daily Allowance for calories and proteins.



The portions are generous, so there is always enough left to share with schoolmates or family.

Ruiru and had the privilege of three meals a day, but many of the kids I played with did not. That led to disparities in opportunities. Unlike others, I was able to go to university,” she says.

Economies of scale

Her first effort raised enough money to set up a makeshift kitchen to serve 100 students. It was such a success that Njiru, who returned to Kenya in 2014, established Food4Education and set up a permanent kitchen at Ruiru Primary School. By 2019, this kitchen was delivering 10,000 meals a



A student receives her Tap2Eat smart wristband. She can use it to make cashless lunch purchases.

day to students at local schools. Njiru's next goal is to provide one million meals by 2026.

At present, the meals are subsidized through donations and profits from a food delivery business. However, to achieve her new goal, Njiru needed to put the project on a more sustainable financial footing. By investing in efficient steam kitchen technology as well as exploiting economies of scale, Food4Education has already brought down the cost per meal by over 40 percent. The aim is that parents' contributions will eventually cover the whole cost. Technology also plays a key role. The students pay

for their meals using Tap2Eat smart wristbands. Parents put money on the wristbands using widely available mobile money services – they do not need a bank account to do this. “The technology helped us to scale up our program from 2,000 to 10,000 children within just a few months,” says Njiru.

Food4Education is already having a tangible impact. “Through my studies I learnt that nutrition affects cognitive ability. Here we have seen that providing school meals not only improves performance, but also reduces absenteeism,” she says. A study of schools participating in Food4Education has shown that they perform on average 20 percent better than schools without feeding programs. They also have more students transitioning to high school.

“School feeding is often seen as a cost rather than an investment,” says Njiru. “Yet according to the UN World Food Programme, for every shilling spent on school feeding, you get 9 shillings back. Nothing in the economy gives a better rate of return than feeding kids.” ■

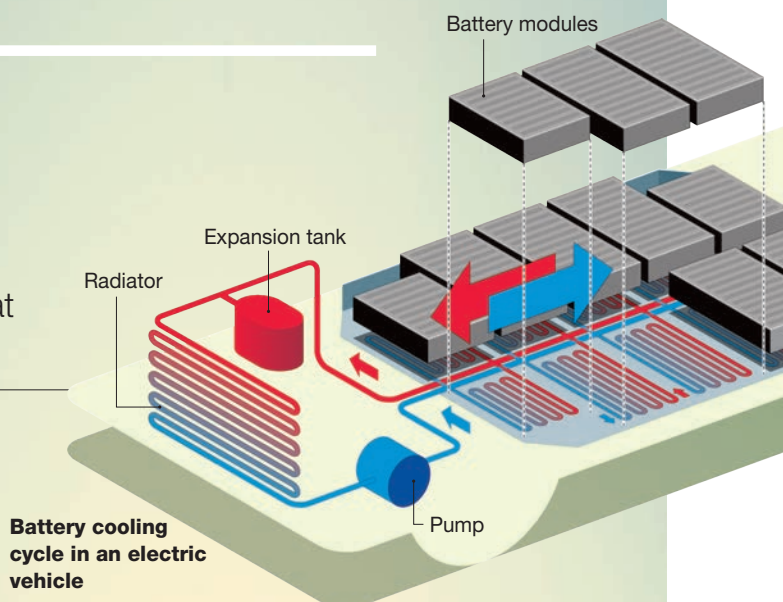
Keep cool

Overheating engines or batteries: There is a cure for that. It looks simple at first glance, but it really does the job.

Do not let it overheat – this is a challenge for combustion engines at high speeds and temperatures. Coolant helps to maintain the best temperature. It flows past the engine, absorbs excess heat in the process, and transports it to the radiator. On average, about 50 liters per minute are pumped through the cooling circuit of an automobile with a combustion engine.


Depending on the type, electric vehicles need twice as much coolant. This is because it is not only the temperature of the engine and the power electronics that has to be kept constant, but also that of the batteries. The fast charging process, in particular, generates a lot of waste heat. Batteries in e-vehicles work best between 20 and 35 degrees Celsius. At temperatures of 45 degrees Celsius and more, they last only about half as long.

Coolants like GLYSANTIN®, which BASF offers for all drive types, are complex products. Glycol, an alcohol, and other additives are diluted with water, usually in a ratio of one to one. The product's composition is adjusted specifically to match the



particular engine and its cooling system and also prevents corrosion. Glycol ensures that the cooling system does not freeze up at low temperatures. Used in the standard ratio, it reduces the freezing point of water to minus 37 degrees Celsius.

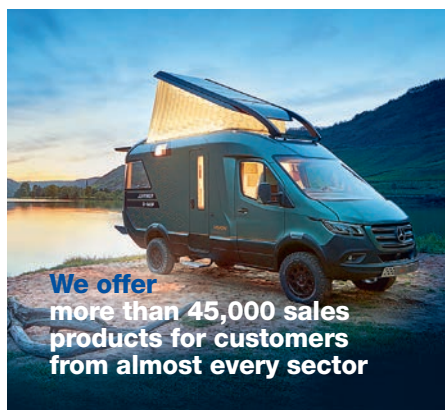
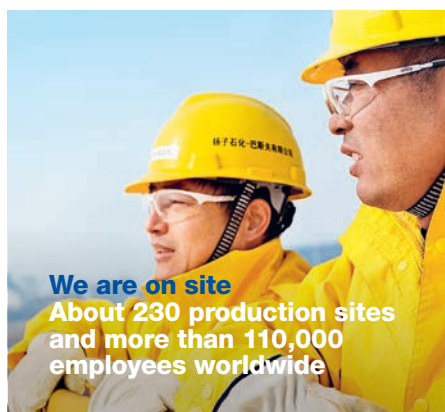
BASF is also developing the GLYSANTIN® ELECTRIFIED™ product family for e-vehicles. It has a relatively low electrical conductivity, which means that smaller amounts of flammable gases are released in the event of a coolant leak. If an accident occurs, this significantly reduces the risk that those gases might be ignited by damaged batteries and set the vehicle on fire.

 [glycantin.com](https://www.glycantin.com)



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