

Creating Chemistry

Collectively intelligent
How research is changing
and building new bonds

No time to waste
A look at Nigeria's
recycling revolution

BASF'S SUSTAINABILITY MAGAZINE



Dare to change

Meet the people who are taking action
to limit global warming

Focus
Climate
protection

The courage for change

In this edition of *Creating Chemistry*, we focus on people who are taking bold steps to address climate change. Meet agricultural pioneers, who are creating healthier ecosystems by protecting the soil and improving its ability to store carbon. And get to know entrepreneurs who are developing innovative sources of energy, enabling cleaner mobility, and finding productive uses for previously discarded resources. Their individual efforts offer meaningful solutions to one of humanity's largest and most complex challenges.



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Bart Van Assche is transforming waste heat into useful power
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Son Nguyen is cleaning up two-wheeled mobility
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Enoch Kofi Boadu is creating fuel from domestic waste
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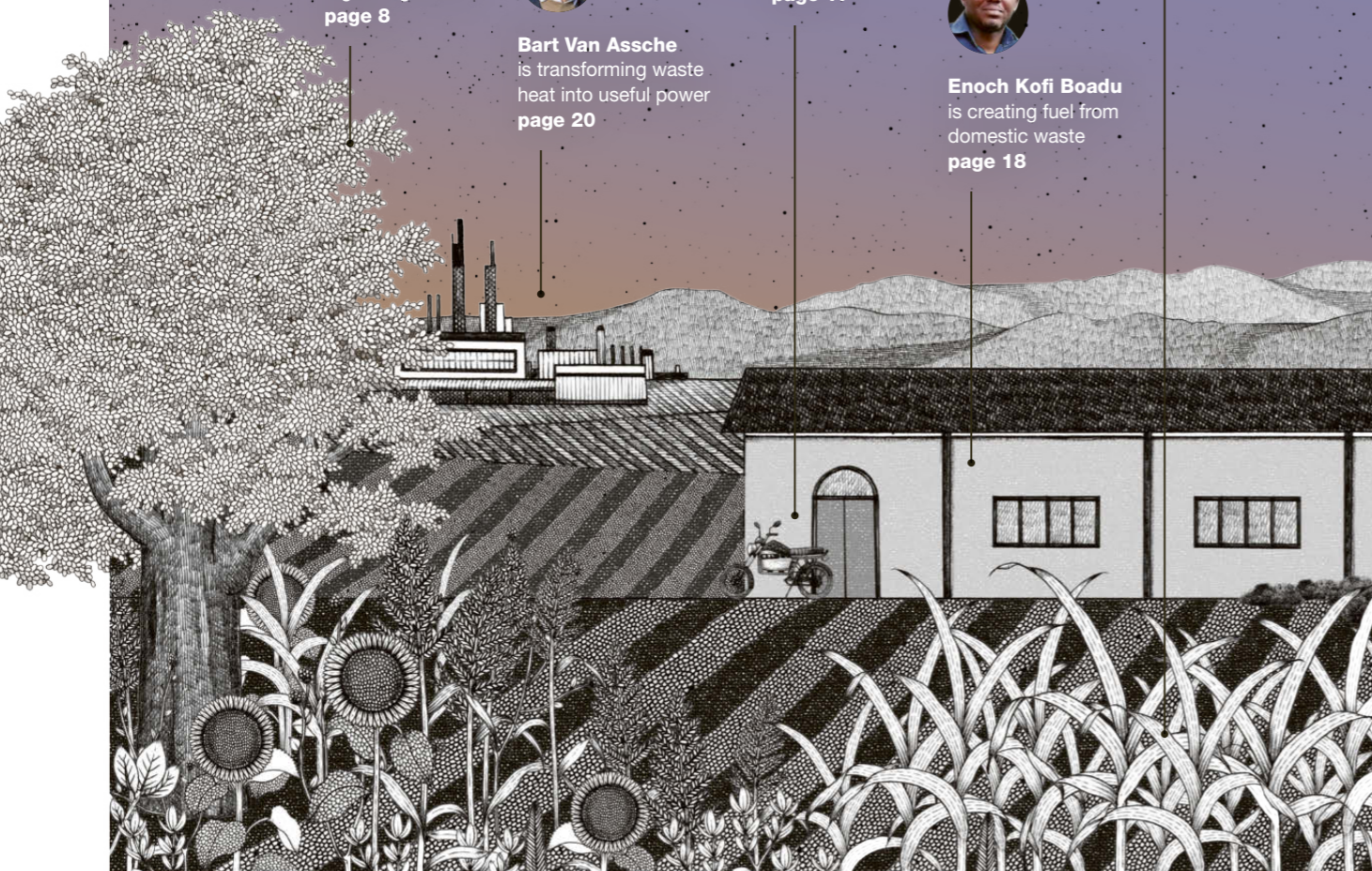


ILLUSTRATION (COVER AND P.2): SUTHIPA KAMYAM; PHOTOS: WORLD VISION; BASF SE/ FOTOSTUDIO SCHWETASCH; DAT BIKE; DAS BIOGAS; JÉRÉMIE SOUTEYRAT; BASF SE

Dear readers,

I invite you to be encouraged, inspired and motivated! This 12th issue of *Creating Chemistry* portrays “doers” who are driving unconventional, but promising approaches to climate protection. Not all ideas will come to fruition, but I am convinced that we have to be bold and try out new things to resolutely counter climate change.

The first part of our cover story is all about opposing global warming, literally from the ground up – by protecting the soil, which is the third-largest carbon reservoir on our planet. Agriculture in particular holds a special responsibility here. William Pitts, a farmer from England, is a pioneer in this area. He applies methods like direct drilling and leaves his soil untilled. With success: Since he has reorganized his farming operations, the soil has stored much more carbon – with the same yield. We as an industry are also working on innovative solutions. Find out more about the BASF Carbon Farming Program, through which we want to contribute to climate-neutral agriculture.

The second part of our cover story focuses on energy. Climate protection can only work if the world becomes independent of fossil fuels. One of the entrepreneurs we introduce here is Enoch Kofi Boadu, who founded a company in Ghana that generates energy from biogas in an environment-friendly way. Like him, we at BASF are focusing on renewable energies and new technologies. Heat pumps are one example of this. Can this technology also work on a large scale at a chemical company? All this and much more is examined within our magazine!



At BASF, we are actively working to shape a future that is worth living – with an innovative spirit, commitment, and passion. The challenges are huge, and the problems are omnipresent. Let us face them with courage and determination.

I wish you much inspiration as you discover this latest issue.

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 share your opinions and ideas with us: creating-chemistry@basf.com



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Meet the changemakers

Our cover story features people who are addressing climate protection with innovative ideas. In the first part, pioneering farmers and agronomists show us how regenerative agriculture and a profitable harvest can go hand in hand. In the second part, we follow the tracks of engineers and entrepreneurs who are driving ways to generate clean energy. **Pages 6–25**

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Climate
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Agriculture and deforestation have depleted the Earth's terrestrial carbon stores. New ideas can protect them.

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To succeed in reducing our emissions, low-carbon energy sources need to be much more accessible.



ILLUSTRATION: SUI HEA KAMYAM; PHOTOS: PICTURE ALLIANCE/ANIP / KEES VAN DE VEEN, JERÉMIE SOUTYRAT, DAT BIKE



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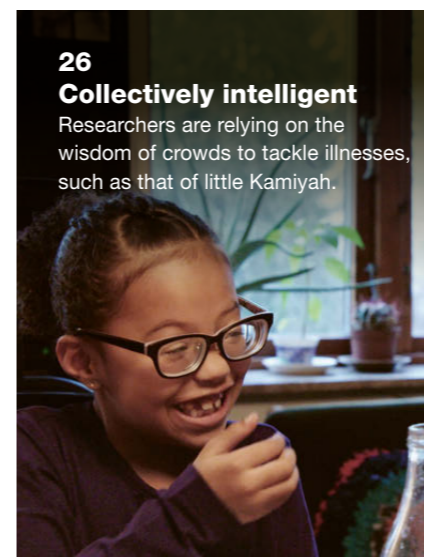
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Collectively intelligent

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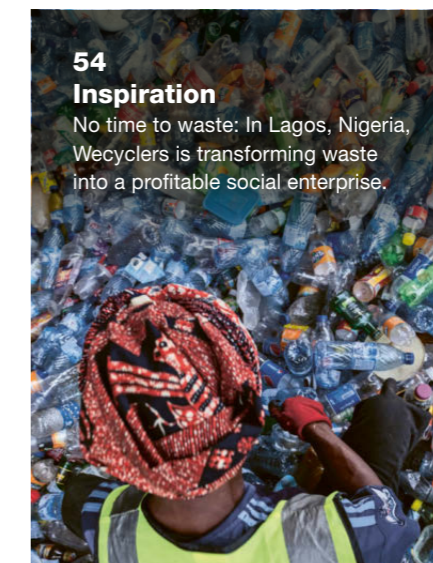
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Take a deep dive into our contents – enriched by videos, interactive graphics and much more.



[basf.com/creating-chemistry-magazine](https://www.basf.com/creating-chemistry-magazine)





From the ground up

The soil beneath our feet is the world's largest terrestrial carbon store. Pioneering farmers and agronomists are working on methods to harness its potential. Their insight: Climate protection and a rewarding harvest can go hand in hand.

Regenerative agricultural techniques help soils capture and store more carbon. That's good for crop yields, and for the planet.

PHOTO: JÉRÉMIE SOUTEYRAT

PHOTO: KENNETH D. CHAMBERLAIN OSU/GFAES



Part I
Soil & trees

Professor Rattan Lal has spent 60 years unlocking the secrets of soils and devising farming methods that can improve them.

The soils of the world contain more carbon than its forests, woodlands and atmosphere combined," says Professor Rattan Lal. Agriculture, by replacing forests with fields, has been depleting that vast carbon store since its birth 10,000 years ago, so "we should see recarbonization of the soil as an essential part of the solution to climate change."

Lal, Distinguished Professor of Soil Science at Ohio State University, United States, stresses that agriculture must become nature-positive. "That means producing more from less: focusing on the efficiency of inputs, rather than the rate." Too many agricultural systems, he explains, rely on very high volumes of fertilizers and other chemical inputs to achieve ▶

their current yields. The alternative regenerative agriculture techniques he espouses are deceptively simple: minimizing tillage, replacing flood irrigation with more water-efficient drip approaches, and using cover crops and agricultural residues to boost nutrients. “And we should use less of the land itself,” he adds. Reducing demand for agricultural products through more efficient utilization and dietary changes would allow more land to be returned to nature, capturing billions of tons of carbon.

In some parts of the world, large-scale efforts to protect the soil are already under way. China’s Three-North Shelter Forest Program, known as the Great Green Wall, is the world’s largest human-made forest. Upon completion in the 2050s, it will span 4,500 kilometers, slowing the southward advance of the Gobi Desert. However, most places don’t have the political, social or economic structures that permit such sweeping changes to land use. The health of their soils depends upon the choices made by millions of individual farmers. That might just be the best place for the next green revolution to begin.

Old trees, new life

Tony Rinaudo, an Australian agronomist, has spent his career helping farmers in the Global South to adopt more sustainable practices. His work began in Niger, West Africa, in the early 1980s. “It was a landscape on the verge of ecological collapse,” he says. Deforestation had stripped protection from the soil, water shortages were rife, and the Sahara Desert was advancing from the north. Rinaudo’s tree-planting efforts were failing, however: “80 or 90 percent of the saplings we planted died or were destroyed.”

He was about to abandon the project. “Then one day I noticed one of the low bushes next to the road, and took a closer look,” he recalls. That bush, like millions of others, turned out to be a tree, regrowing from a leftover stump. “In that instant, everything changed. We didn’t need millions of dollars to make a dent in this. We didn’t need a miracle species of tree that could withstand droughts and people pulling them up. Everything you needed was literally at your feet.”

“**After 20 years, we had 200 million trees, without planting a single one.**”

Tony Rinaudo
Agronomist



Known as “the forest maker,” Tony Rinaudo helps farmers in Africa and beyond to protect their soils by regrowing trees from left over stumps when land is cleared.

With well-established root systems to access water and nutrients from deep in the soil, trees that regrow from stumps are much more likely to survive than new seedlings. That revelation shifted Rinaudo’s approach. He started a new project, incentivizing farmers to allow a few trees – 40 per hectare – to regrow on their land. “They thought the idea was strange, but a minority could see it was doing some good,” says Rinaudo. “A little more organic matter was going into the soil, wind speeds were slower, the temperature was lower, and some of the traditional wild foods were coming back.”

In the following years, Rinaudo’s “farmer-managed natural regeneration” approach steadily took root in Niger. “After 20 years, we had 200 million trees across 5 million hectares, without planting a single one. All from an investment of about two U.S. dollars per hectare,” he says. Mature trees each absorb about 25 kilograms of

carbon from the atmosphere every year, and more is captured by the improved soils on regenerated farms.

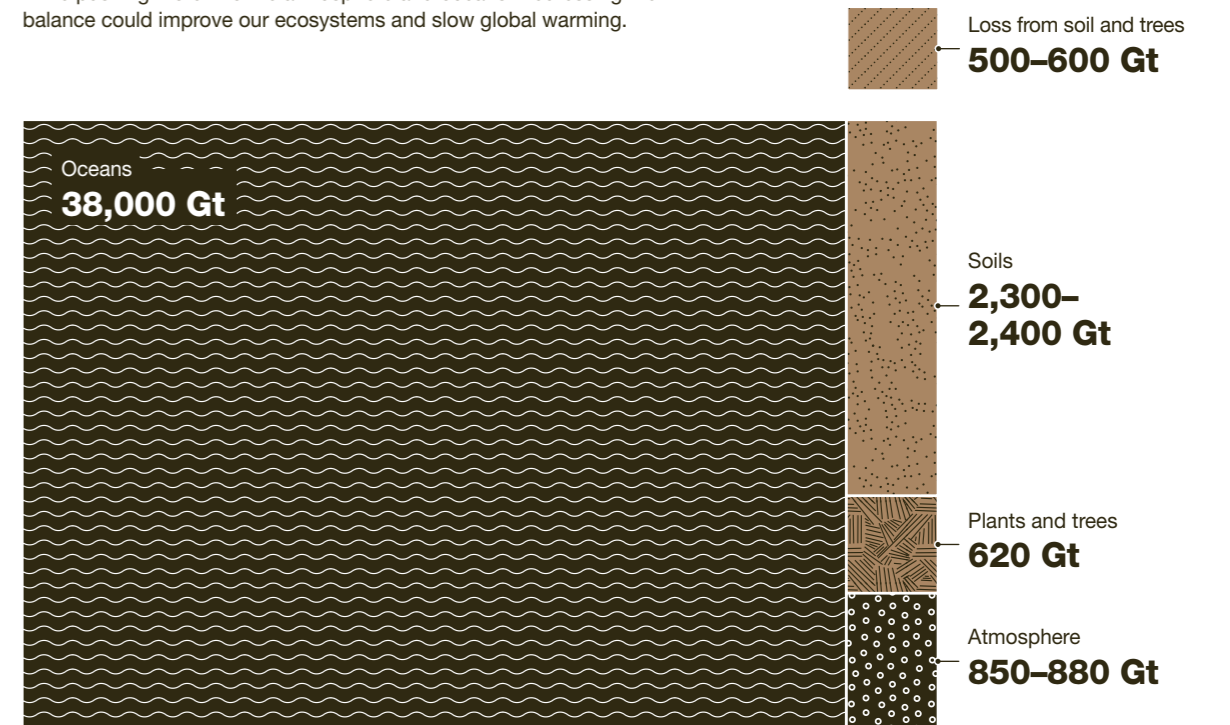
Rinaudo and his current employer, the charity World Vision, went on to launch projects in other African countries, including Ethiopia, Ghana and Senegal. Today, farmer-managed natural regeneration is used in about 25 countries. Most common in Africa, it has also been adopted in countries such as Indonesia, Myanmar and East Timor.

Pulling the plow

Climate and environment-sensitive practices are gaining momentum in the rich world and in conventional agriculture, too. William Pitts grew up on an arable farm in Northamptonshire, England, which he now runs alongside his brother. The business grows grains on around 800 hectares. “We now manage about 10 percent of our farmland for the environment: ▶

Storing carbon naturally

Human activity is reducing the carbon stored in soils and biomass, while pushing more into the atmosphere and oceans. Redressing the balance could improve our ecosystems and slow global warming.





William Pitts has switched from conventional plow-based agriculture to no-till techniques across his farm in England.

“**The organic matter content of the soil has doubled since we adopted zero tillage.**”

William Pitts
Farmer
England

flowers, butterflies, flora and fauna. And the rest of it we try to farm in a way that protects the soil as much as we can,” Pitts says.

That desire to conserve the soil has led the Pitts to gradually abandon the plow. Today, they use direct drilling equipment that deposits seeds into a narrow slot in the surface of the soil. A strategy that once looked radical is now paying off: Yields on the Pitts’ farm are as high, and sometimes even higher, than they were, but its costs have fallen significantly. “Under our old system, we would use 120 liters of diesel per hectare across a year’s cropping cycle,” he says.

“Today, we have managed to cut that down to 70 liters, which is a significant 40 percent reduction.”

The land is holding more carbon too. “Tests have shown that the organic matter content of the soil has doubled since we adopted zero-tillage techniques,” says Pitts. That’s good for the crops, but for a growing number of farmers around the world, the soil’s ability to capture more carbon from the atmosphere is also becoming a source of income.

Carbon as a crop

Kasey Bamberger is part of a family partnership that grows corn, soybeans ▶

PHOTO: JÉRÉMIE SOUTEYRAT

Nitrogen

N

Atomic number
7

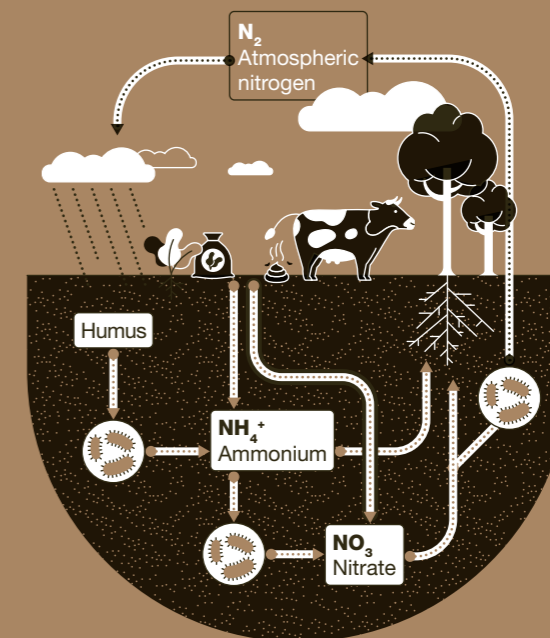
Physical state
Gaseous

Occurrence
Fifth-most common element in the universe

Discovery of the elementary form
In 1772 by the Scottish professor of botany, Daniel Rutherford

Production
The world’s first ammonia synthesis plant using the **Haber-Bosch process** started operating at BASF in 1913. This process uses nitrogen from the air, and was awarded the Nobel Prize in 1918.

Essential for life, useful and harmful. Nitrogen is part of our DNA – we need it to form amino acids and, from them, proteins, of which we consist. However, although around 78 percent of the air we breathe by volume is composed of this inert, odorless, colorless gas, we cannot absorb nitrogen in unbound form from the air. We take it in through our food. Plants extract nitrogen compounds for photosynthesis from the soil. Since these compounds enable plants to grow well but are often in short supply in the soil, they are produced industrially as fertilizers. Their source material is usually ammonia, a compound of nitrogen and hydrogen. Between 75 and 90 percent of the ammonia produced worldwide is used as a growth promoter. However, plants absorb on average only around 50 percent of the nitrogen provided this way, with large regional variations. This results in nitrogen losses – a burden on soil, water, and air.



The natural nitrogen cycle
How organisms convert atmospheric nitrogen into reactive nitrogen and use it as a nutrient.

Uses of nitrogen



Shock freezer

Liquid nitrogen is suitable for quick-freezing and cooling foodstuffs or blood reserves.



Growth promoter

Fertilizers contain nitrogen atoms, meaning bound nitrogen, which builds vegetable protein.



Flavor preserver

As a packaging gas, nitrogen expels oxygen from food packaging. This means our food retains its color, shape and flavor for longer. The designation E941 denotes the nitrogenous, harmless additive.



Tire protector

Aircraft tires often become very hot on landing. To prevent them from catching fire, they are filled with nitrogen.



Explosive

Nitrogen compounds can be used to make nitric acid – and from that, explosives can be made.



Anesthesia assistant

Nitrous oxide, better known as laughing gas, is used as an anesthetic.



Reaction preventer

Inert nitrogen gas is used in lead-free soldering to prevent oxidation.

GRAPHIC: ASCS / JULIA ZIMMERMANN

and wheat on around 8,000 hectares of land in southwest Ohio, United States. “We’d heard a lot of discussion about climate change, but we really started to see its impact at first hand in 2018,” she recalls. “The weather patterns in our area began to change, we were seeing some topsoil loss, and experienced different weed pressures. That was the catalyst for our farm to start exploring the potential of regenerative agricultural practices like reduced tillage and planting cover crops.”

While it promises significant benefits over the long term, the transition presented extra costs and risks. “We’ve already had things go wrong,” she says. “We’ve had to cut and remove cover crops that grew too much in wet weather, for example. That’s not such a big deal on 200 hectares, but when you think about over 2,000 hectares, it makes your head spin.”

For the past two years, the business has joined a carbon offsetting scheme, which pays it for every ton of carbon added to the soil. The money comes from companies and individuals around the world, who buy carbon credits to offset their emissions. The price varies according to shifts in global carbon markets. With new practices currently adding 2 to 4 metric tons of carbon per hectare every year, those payments are a useful financial buffer. The system could benefit farmers of all scales, in all regions worldwide.

Grounds for gains

The agricultural products and services sector has its own role to play in the growth of regenerative farming. “Our agricultural food system will undergo an accelerated transformation in order to provide enough healthy and affordable food for our growing population. At the same time, it will need to mitigate its impact on our planet,” says Dirk Voeste, Senior Vice President Regulatory, Sustainability & Public Affairs at BASF’s Agricultural Solutions division, Limburgerhof, Germany. “At BASF we are helping farmers worldwide, like William Pitts and Kasey Bamberger, to tackle the most pressing climate challenges. We provide the right combination of technologies to increase yield with reduced environmental impacts, and make their farm management easier and more

“**We have really started to see the impact of climate change at first hand.**”

Kasey Bamberger
Farmer
United States

Kasey Bamberger’s business earns carbon credits when it uses regenerative techniques to improve the soil.

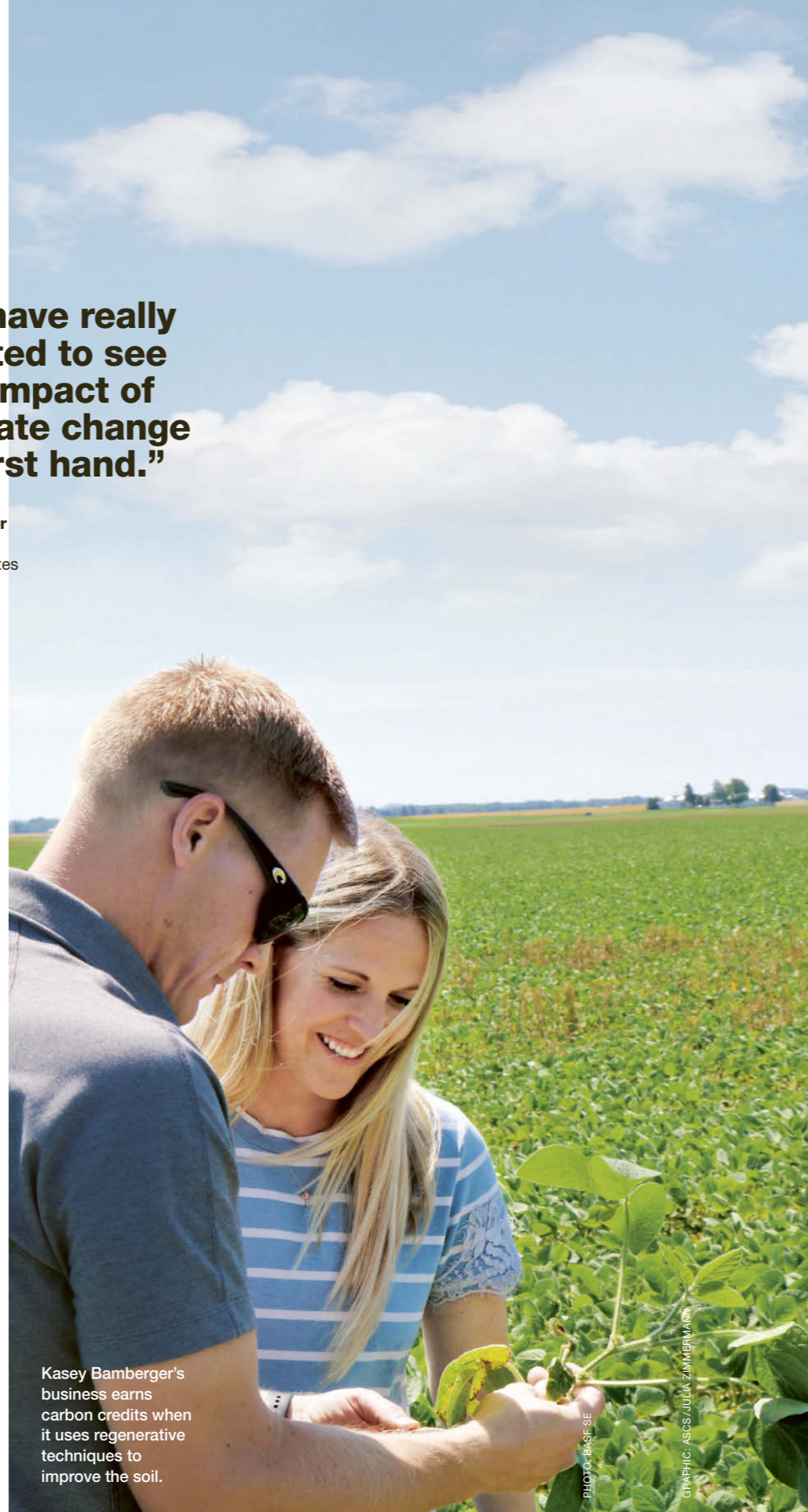
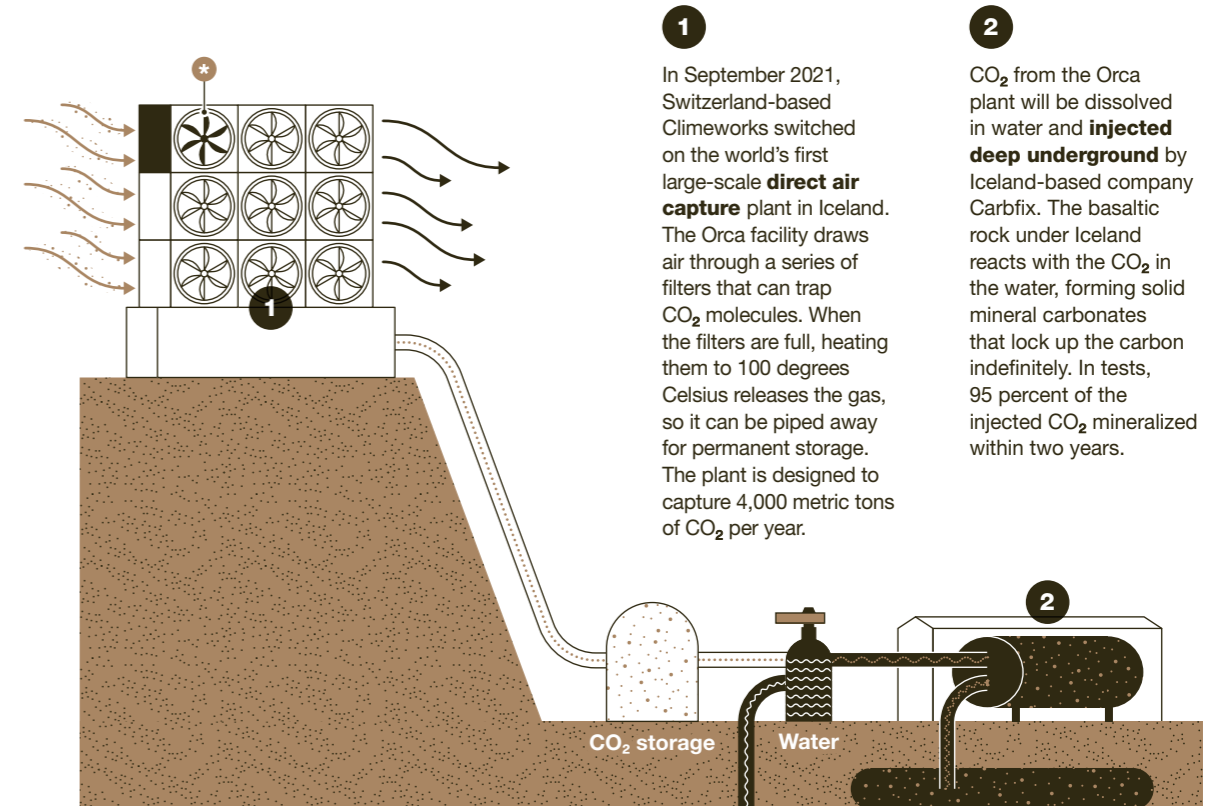
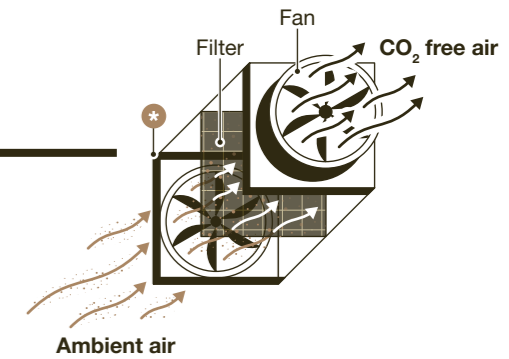


PHOTO: BASF SE
GRAPHIC: ASCS, JULIA ZIMMERMANN

An injection of technology

Helping nature remove CO₂ from the atmosphere and the seas – is this possible? Geoengineering approaches propose using technologies at huge scale to trap and store CO₂. One way to do that is by turning carbon into stone.



1

In September 2021, Switzerland-based Climeworks switched on the world’s first large-scale **direct air capture** plant in Iceland. The Orca facility draws air through a series of filters that can trap CO₂ molecules. When the filters are full, heating them to 100 degrees Celsius releases the gas, so it can be piped away for permanent storage. The plant is designed to capture 4,000 metric tons of CO₂ per year.

2

CO₂ from the Orca plant will be dissolved in water and **injected deep underground** by Iceland-based company Carbfix. The basaltic rock under Iceland reacts with the CO₂ in the water, forming solid mineral carbonates that lock up the carbon indefinitely. In tests, 95 percent of the injected CO₂ mineralized within two years.

Locking it up

BASF is also looking at ways to capture and store CO₂. For example, in a project with Air Liquide, where the company is developing the world’s largest cross-border carbon capture storage (CCS) value chain at its Verbund site in Antwerp, Belgium. The goal: transport CO₂ to offshore sinks using the port of Antwerp-Bruges’ infrastructure.

effective. And we are exploring ways to help incentivize carbon efficiencies.”

The company has committed to enabling a 30 percent reduction in CO₂ emissions per ton of crop by 2030. As part of that effort, BASF launched its own Global Carbon Farming Program in 2022. Through a multi-year series of field trials, it aims to find the best ways to help farmers cut their carbon emissions and increase sequestration. It also includes a global framework that will allow farmers

to access carbon credits from recognized certifiers.

And what does “the father of soil science,” Professor Lal say? “Payments for carbon should be universally available to farmers. Let’s move away from subsidies and start paying for ecosystem services,” he says. “Let’s pay a fair price per ton for carbon sequestration in soil and trees. And let’s pay it transparently and directly to the people who do the work.”

Life on a hot planet

We need to act fast to stay cool. Climate change is already having profound, diverse and highly visible effects. Without concerted action, warming is forecast to accelerate, potentially as high as 5.7 degrees Celsius, by the end of this century. Discover how a heating planet influences the environment, nature and humanity. And why the world needs decisive action now.

Methane release

The thawing of Arctic permafrost allows methane from decaying organic matter and the rocks below to escape into the atmosphere, adding to the greenhouse effect.

Source: PNAS

Vanishing kelp forests

Shallow water kelp forests store carbon, reduce coastal erosion, and provide a habitat for hundreds of marine species. Warmer waters are altering the balance of those ecosystems, sometimes with devastating effects. Since 2014, 95 percent of California's kelp forests have disappeared.

Source: Communications Biology

Increased volcanic activity

As glaciers shrink, their lower mass reduces pressure on the Earth's crust. That allows more magma to flow to the surface, leading to larger and more frequent volcanic eruptions in icy regions.

Source: Geology Journal

Wild fires

Forest fires spread quickly in hot, dry and windy weather. Between 2010 and 2019, the average area of forest lost to fire every year increased from around 50,000 to 80,000 square kilometers.

Source: Frontiers in Remote Sensing

But there is hope:

Discover encouraging approaches online at basf.com/act-fast



Pests on the march

Warmer summers and milder winters can be a boon to agricultural pests. The range of the European corn borer, for example, is expected to shift northward by more than 1,000 kilometers this century.

Source: Insects Journal

Costly healthcare

By 2030, the World Health Organization expects malnutrition, malaria, diarrhoea and heat stress linked to climate change to increase healthcare costs by 2 to 4 billion U.S. dollars per year.

Source: WHO

Eroding coastlines

Rising sea levels are already reshaping the world's coastlines. A 2020 study by the European Commission Joint Research Centre predicts that half the world's sandy beaches could disappear by the end of this century.

Source: JRC

Rushed migration

In warmer springs, barnacle geese accelerate the migration to their arctic breeding grounds. With less time to feed en route, they arrive in poor condition, lay their eggs later, and fewer offspring survive.

Source: ERC

Energetic innovators

For climate-conscious living with a small carbon footprint, access to alternative energy sources is crucial. Innovators and entrepreneurs from around the world are finding approaches to emissions reduction that meet the needs of individuals, households and companies.

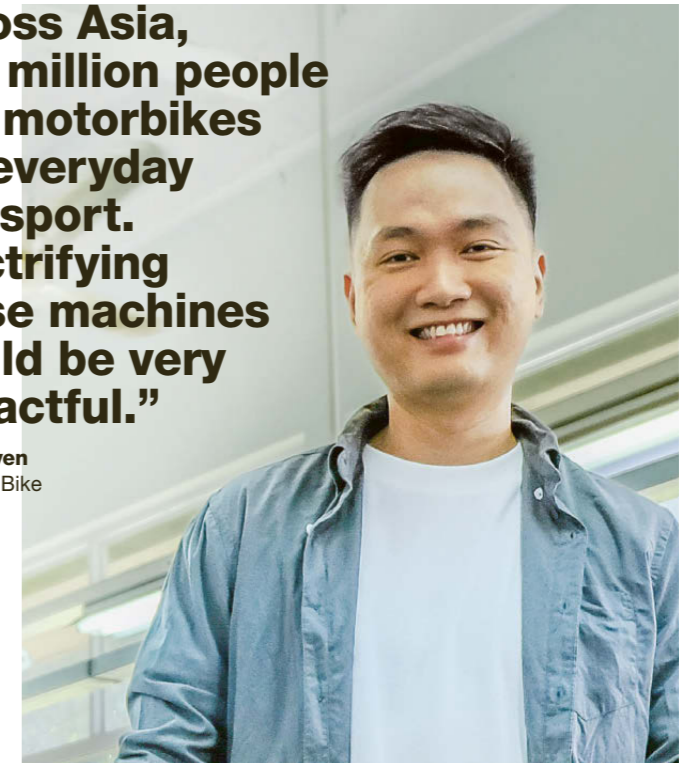
Dat Bike makes Vietnam's first domestically produced electric motorbikes. The company aims to match gasoline machines for price and performance.

Part II
Energy

“

Across Asia, 250 million people use motorbikes for everyday transport. Electrifying those machines would be very impactful.”

Son Nguyen
CEO, Dat Bike
Vietnam



Together, energy consumed in buildings and transport accounts for just over 30 percent of total greenhouse gas emissions. Private consumption, in domestic dwellings or for personal transport, makes up more than half of that. Climate-minded consumers already have choices if they want to stick within their personal carbon budget. They can buy renewable energy, or switch to an electric car, for example. Those solutions are not within everyone's reach, however. Even in industry, where energy consumption accounts for around a third of global CO₂ emissions, low-carbon technologies can be difficult to plug into existing plants and processes. To meet its emissions reduction targets, the world needs to make low carbon energy much more accessible.

A clean pair of wheels

Son Nguyen, founder and CEO of electric motorcycle company Dat Bike, is on a mission to make electric transport accessible to millions. Born and raised

in Vietnam, Nguyen's skills as a high-school computer programmer earned him a place at the University of Illinois, United States, and led to a role as a software engineer in a Silicon Valley firm.

Splitting his time between the United States and Vietnam made Nguyen acutely aware of the different directions the two countries were taking in mobility. Electric cars were becoming commonplace on the streets of California, but “at home in Vietnam, more people moving into cities led to lots of polluting gasoline-powered motorbikes on the streets.” Across Asia, he says, there are 250 million people who use “a gas guzzling motorbike” as their everyday transport. This made him think that electrifying those machines could be “a solution to a very impactful problem.”

There was just one catch: Nguyen had no experience in motorcycle design, or electric powertrains, “so I quit my job and started learning.” Over the next few months, he put himself through a crash course in engineering to pick up critical skills, such as welding. Within a ▶

PHOTOS: DAT BIKE

year, he had made his first prototypes. Showing them online attracted some early investors. It was time to go back home.

Arriving in Vietnam to set up Dat Bike, Nguyen had two priorities for his product: It should match its fossil-fuel counterparts for price and performance, and it should be locally manufactured to the highest degree possible. After a TV appearance, the tiny company was inundated with inquiries from potential suppliers and investors. Six months later, its first machines rolled off the production line. With more than 80 percent of its suppliers located in the country, Dat Bike's Weaver model was Vietnam's first domestically produced electric motorbike.

The machines are a hit. Dat Bike increased its manufacturing capacity fivefold during the first half of 2022, but its latest Weaver 200 model bikes were still sold out months in advance. So far, customers are willing to wait. "There's nothing like it on the market," says Nguyen. "Ride one for five years and the fuel cost savings alone mean you effectively get the bike for free."

Now we're cooking with gas

In Ghana, 12,000 kilometers west of Vietnam, Enoch Kofi Boadu has built a business enabling customers to create clean energy for free. DAS Biogas builds and installs systems that can transform waste into cooking fuel. Biogas is a mixture of methane and carbon dioxide generated by bacteria that decompose organic material in the absence of oxygen. Today, it is produced on an industrial scale at plants fed by sewage or agricultural wastes. DAS Biogas, however, is creating household-scale units that are robust, cheap and easy to install.

The idea was born when Boadu was a high-school science and technology teacher. "I used to run a lot of experiments with my students, and we started making biogas in small containers," he recalls. "That made me realize that this technology had a lot of potential." Boadu's experiments have continued ever since. "We pursued different approaches, but I really wanted to make a portable plant that we could produce at scale and install across Ghana and beyond," he says.

The first DAS Biogas Prefab1 plants entered the Ghanaian market during the summer of 2022. For 1,300 U.S. dollars, customers receive a biogas digester, a gas storage bag, and a single burner stove. "The whole system is made locally," he explains. "The tanks are molded in plastic by a local company, and we also use local sources to weld the bags that store the gas."

The plants can be installed outside a house to convert kitchen waste such as food, fruit and vegetable waste to cooking fuel. Or they can be built into it during construction to additionally convert sewage. The effluent undergoes further treatment in a secondary unit to ensure that the treated water meets all relevant environmental discharge standards, allowing it to be reused for garden irrigation or flushing toilets.

The system generates around one cubic meter of gas per day, enough to meet more than half the cooking needs of a typical Ghanaian household. This ultimately reduces the need to use LPG, electricity or wood. Each unit, says Boadu, saves between 3.7 and 5 metric tons of CO₂ per year. By late autumn 2022, ▶

“I wanted to make a portable biogas plant that we could produce at scale.”

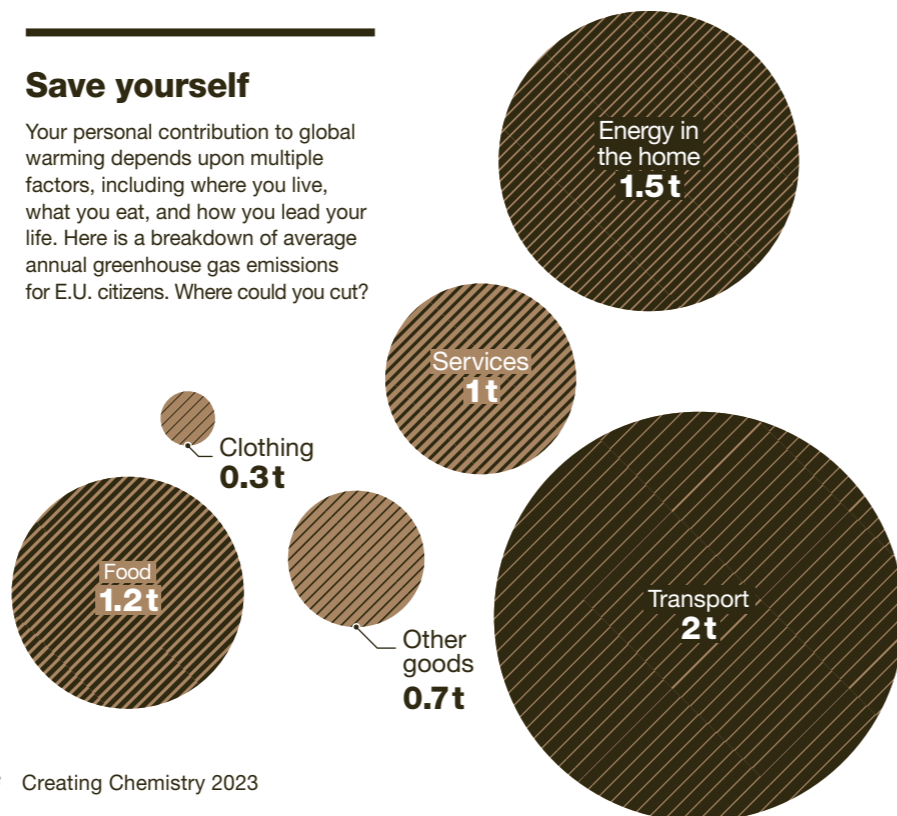
Enoch Kofi Boadu
CEO, DAS Biogas
Ghana



The DAS portable biogas plant transforms a household's waste into enough fuel to meet at least half its cooking needs.

Save yourself

Your personal contribution to global warming depends upon multiple factors, including where you live, what you eat, and how you lead your life. Here is a breakdown of average annual greenhouse gas emissions for E.U. citizens. Where could you cut?



Smart decisions by humanity

When stakeholders get together around a common cause, positive change is possible. Here are three ways that international agreement has made a real difference to the world.

1 Marine mammals: Ending the hunt

During the 20th century, almost 3 million whales were killed for their meat and oil. The International Whaling Commission declared a pause in commercial whaling from 1985. Since the moratorium, legal annual catches by fleets have fallen to around 800 animals.

2 The ozone layer: Loophole closed

Ozone-depleting chemicals such as chlorofluorocarbons (CFCs) were once common in aerosols, fridges and hundreds of other products. Since the Montreal Protocol came into force in 1989, use of these materials has dropped by 98 percent. The stratospheric ozone layer, which protects our planet from ultraviolet radiation, is now recovering.

3 Petrol additives: A brighter idea

Lead-based additives in vehicle fuels have been linked to heart disease, strokes, cancer, and problems with brain development in children. Industrial countries began to phase out their use in the 1970s, and, after a long campaign by the United Nations Environment Programme, worldwide use of leaded fuels in cars and trucks finally ended in 2021.

the company had made and installed 20 systems, and it plans to increase production fivefold in 2023.

Full steam ahead

While DAS Biogas and Dat Bike are scaling down low-carbon technologies to meet the needs of homes and individuals, BASF is now scaling up approaches that work in households to an industry level. About half of BASF's current carbon footprint comes from energy generation on its sites, and of that 11 million tons, 6 millions comes from the production of steam. "Finding ways to reduce emissions associated with steam has become a significant focus over the past two years," says Bart Van Assche, Vice President Global Infrastructure Technology at BASF, based in Ludwigshafen, Germany.

One promising approach is the transformation of waste heat into useful energy using a technology that is already found in many homes: the heat pump. Heat pumps use the compression and expansion of a gas to transfer energy from a lower temperature source to a higher destination. Since every kilowatt hour of electricity used to run the pump produces several

kilowatt hours of heat, they are an efficient way to keep homes warm. "In each of our five largest production sites, we know that there's more than enough energy in waste heat to meet our steam requirements," says Van Assche.

The heat pumps Van Assche's team is investigating differ from domestic units in two important ways: temperature and scale. "Temperatures will be much hotter and will generate steam at more than 120 degrees Celsius." That low-pressure steam can then be compressed, heating it even more, and injected into the steam grid at a site. Running the heat pumps and compressors using electricity from renewable sources will contribute significantly to reducing CO₂ emissions. Industrial heat pumps will also be orders of magnitude bigger than home units. "We are currently doing detailed studies for the first heat pump projects, and they are the size of football fields," he says. Integrating such large pumps into a busy chemical site is challenging, but BASF expects its first steam-generating heat pumps to enter operation in 2026.

The new heat pumps will be part of a multi-pronged approach to steam

decarbonization. BASF is also looking for ways to reduce steam demand, such as by replacing steam-powered drives with electric motors, and it is investing in boilers powered by renewable electricity.

There won't be a one-size-fits-all answer to the low-carbon energy challenge. But ongoing innovation in a wide range of technologies means people have an ever-increasing chance of finding sustainable solutions to suit their needs. ■

“

Our planned heat pumps will be the size of football fields.”

Bart Van Assche
Vice President Global Infrastructure Technology, BASF

Each of BASF's five largest production sites generates enough waste heat to meet its own demand for steam.

Lithium

Li

Atomic number
3

Physical state
Solid

Occurrence
As a proportion of the Earth's crust, it makes up 0.002–0.006 percent.

Discovery
In 1817 by the Swede Johan August Arfwedson



In 2019, the **Nobel Prize for Chemistry** was awarded for the development of the lithium-ion battery to John Goodenough, Stanley Whittingham, and Akira Yoshino.

Lithium is the flyweight among the solid elements at room temperature. In nature, this reactive alkali metal occurs only in compounds. It is small and light, and highly mobile as an ion. Lithium-ion batteries are hard to beat, especially in e-mobility. They not only charge faster than lead-acid batteries, but can also store more energy in the same amount of space. As a result, they have a greater range. The huge level of demand is leading to bottlenecks, but natural reserves are high. According to estimates by the U.S. Geological Survey, three-quarters of

the world's lithium resources of about 70 million metric tons are still lying untouched, mainly in the rocks of Australia or the salt lakes of South America. However, lithium mining is controversial: According to critics, its extraction from concentrated brine leads, for example, to water scarcity in areas that are already dry.

Lithium quantities

How much lithium is needed for different batteries.

1.1 grams
for 10 Wh



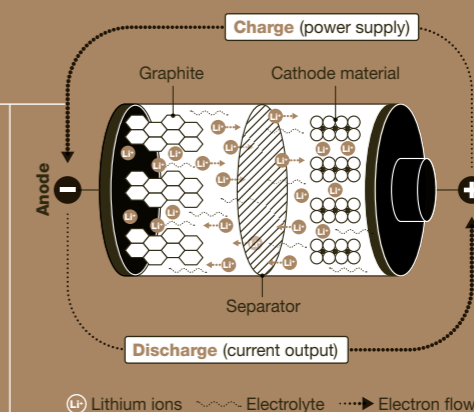
6.4 grams
for 60 Wh



6.9 kilograms
for 65 kWh



Source: BASF Cell Calculator



Energy store

Lithium is mainly part of a battery's positive electrode. When the battery is charged, the lithium ions flow to the negative electrode.

Uses of lithium



Kitchen helper

On a cooker, lithium carbonate prevents ceramic hobs from cracking at high temperatures.



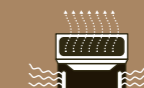
Thickener

Lithium hydroxide thickens greases and oils for automobiles and aircraft.



Drier

Lithium chloride can absorb large quantities of water. In industrial applications, it dries industrial gases and cools the air.



Air cleaner

Lithium hydroxide is used in submarines or rockets as a strong CO₂-absorbing air cleaner.



Color provider

Lithium carbonate creates deep red effects in fireworks.



Lightweight

Aluminum alloys with lithium are stable and light at the same time. They are, for example, used in aircraft or in vehicle construction.

Are you keen to be green?

Countering climate change calls for major lifestyle change, says Linda Steg. How can people be persuaded to make that shift?

Linda Steg

For more than 25 years, Steg has examined the interactions between people and the environment, with particular focus on how environmentally friendly behavior can be encouraged.

Steg, Professor at the University of Groningen, Netherlands, is one of the authors of the 2022 Sixth Assessment Report published by the Intergovernmental Panel on Climate Change (IPCC), the United Nations body assessing the science related to climate change. As a member of IPCC Working Group III, she focuses on climate change mitigation. In 2020, she was awarded the renowned Stevin Prize.



PHOTO: PICTURE ALLIANCE / ANP / NEES VAN DE VEEN

Climate change forces us to self-reflect and causes remorse, since many of the everyday decisions we make as individuals, and as society, influence the pace of global warming. But even when we know the facts, we don't always make the best choices for the planet. Dutch environmental psychologist Linda Steg argues that the transition to a sustainable society will only succeed if our beliefs, preferences and behaviors are taken into account.

Why is environmental psychology important in countering climate change?

Because climate change is not just a technical or natural science issue, but also a behavioral one. The way we think, the choices we make, the way we act – all these have major implications for climate change and the quality of the environment. But we can also affect environmental quality by more political behavior: by protesting, by boycotting organizations or companies, or by voting for parties that are likely to implement green policies. So, if we can act differently and engage more in sustainable behavior, that would help limit climate change. And in fact, many solutions, such as establishing wind parks or nuclear power plants, are difficult to implement if people strongly oppose them.

Faced with a problem as big as climate change, isn't it natural for people to think that their own actions won't make much difference?

Each individual has a small influence indeed, but as a collective we can have a major one. What we find consistently in research is that the more people care about nature and are aware of their impact on environmental problems, the more they acknowledge that their contribution matters – not only through our personal impact but also because we might inspire and motivate others to act. Because people are influenced by the behavior of other people around them. For example, homeowners are more likely to install solar panels when others in the neighborhood have also done so.

PHOTO: LAF / REDUX / THE NEW YORK TIMES / OLIVIA HARRIS

What matters more: the behavior of individuals, or the behavior of governments, corporations and other institutions?

Environmental psychologists used to focus primarily on individual actions. But more and more we acknowledge that behavior is also dependent on choices that other actors make, such as industry or politicians. And these choices are, in the end, also made by individuals. As a result, we are now also looking at what increases the likelihood of companies or politicians taking actions that support or enable people to engage in climate action. Because, in the end, they shape the context in which our choices are made.

What will encourage people or organizations to change?

One important thing is that we understand how people perceive the likelihood that others will act. We know from individual consumers that they tend ▶

“People tend to underestimate the willingness and environmental values of others.”

Inspired by activist Greta Thunberg, the youth-led Fridays for Future movement has organized worldwide protests for action on climate change.



to underestimate the willingness and environmental values of other people. And that might inhibit their own actions. But the same might happen at different levels, right? Companies might think, yes, I can offer sustainable products, but no one will be willing to buy them. And people might think, well, the companies don't offer sustainable products, so I can't do anything. Or a politician might think, I'm not going to implement this policy, because then people will protest, and I won't get reelected next time. Part of my current research is looking at how decision-making changes when all the actors involved understand how much the others care about climate change, and how willing they are to take action to mitigate it.

What can policymakers do to encourage pro-environmental behavior?

There's a relatively high potential for commitment strategies. For example, asking people to make a pledge or promise to act in a certain way, such as a pledge to cycle rather than drive to work. Another impactful strategy could be a bottom-up initiative, such as local energy initiatives. Individuals are more likely to trust and be influenced by people who are like them, and they can demonstrate what climate-conscious behavior would look like and point out its advantages. Or sometimes you just need simple reminders, small prompts such as a sign in the office canteen saying, "why not have a vegetarian meal today?" That works particularly well when people already have the will, but don't always make rational or deliberate decisions because they're not thinking about it.

What is the difference between extrinsic and intrinsic motivation, and what role do they play in changing behavior?

Extrinsic motivation is doing something because you think you'll be rewarded, or if you don't, you'll receive a punishment. It's the carrot and the stick principle. For example, people may drive less because road pricing is implemented. Intrinsic motivation comes from within, along the

To encourage people to switch from cars to bikes, the French capital Paris has built hundreds of kilometers of new cycle lanes since 2014. Mayor Anne Hidalgo has pledged to make the city "100 percent bikeable" by 2026.



“Making one or two small changes will not do the trick. We need major lifestyle transformation.”

lines of, "I do it because it's important to me, and I care about the environment." And doing it also makes you feel good. It gives you a warm glow. Sometimes an extrinsic motivator can trigger behavior change and enable people to act on their intrinsic motivation.

Many people care about the environment, meaning they are intrinsically motivated to act. But they don't always act that way because it can be cumbersome or unattractive. So, our suggestion as environmental psychologists is, if you provide a subsidy or increase the tax on the unwanted behavior and clearly link it to the benefit of the environment, then you can still make the link to the intrinsic motivation.

In your recent collaboration for the IPCC report, what kind of behavioral scenario studies have you done?

In the IPCC report, we present studies that try to establish how much climate change



People are more likely to install solar panels on their homes when they see that their neighbors have done so.

PHOTOS: LAIF/REDX/THE NEW YORK TIMES / DMITRY KOSTYUKOV, GETTY IMAGES/ISTOCKPHOTO/QUERBEET

can be reduced by looking at changes in demand. If you approach it from the demand side, then theoretically you could reduce overall emissions by 40 to 70 percent compared to the status quo. These are substantial figures, which can be achieved by, for example, switching to sustainable transport options, eating fewer animal-based products, and making our homes more energy-efficient.

To achieve those changes in demand, we may also need to change our systems – transport, infrastructure, financial, social – the context in which we make our choices. Because currently, in many situations, acting pro-environmentally is costly or inconvenient. For example, flying is often inexpensive, at least if you book ahead. You can fly from one side of Europe to the other for a few euros. And the train is mostly more expensive, and more cumbersome, because you have to transfer often. The incentives are pointing you in the wrong direction, even if you're

motivated to limit climate change. Paying the true price for goods and services, including the cost of the pollution involved in their creation, would be one incentive towards climate-friendly behavior. I would make flying more expensive. Meat consumption, too.

How do psychological factors influence our systems?

Systems are influenced by people who make decisions on how the system works. I'm now trying to set up research to understand how individuals in influential positions take decisions that affect the choices the rest of us can make. The financial system is important here: from how the money flows to which behavior becomes attractive in the end. For example, pension funds make investments, and pension funds invest money that we give to them. One of the conclusions of the IPCC report is that the fossil fuel sector is still receiving more investment than the renewable energy industry. That implies that we are still stimulating a fossil fuel-based economy rather than a renewable energy-based economy. In these cases, the incentives need to change as well.

How can you gain support for change?

What is evident is that people do accept some cost for behaving sustainably, financially and in terms of convenience, as long as the way in which costs and benefits are distributed is transparent and fair. And it is not so much that people want every decision to benefit them directly. They do understand that sometimes there are also other interests at stake. Consulting the public and facilitating their participation in the decision-making process communicates that sense of fairness.

Where do you see future potential for environmental psychology to help individuals become keen to be green?

I'm currently most interested in lifestyle changes, because making one or two small changes will not do the trick. We need major lifestyle transformation, and I want to understand what will motivate people to systematically switch their behavior to low-carbon lifestyles. ■



“**Crowdsourcing has fundamentally changed my life as a researcher.**”

Professor Andrea Meredith
School of Medicine, University of Maryland,
United States

PHOTO: UNIVERSITY OF MARYLAND/TOM JEWSKI; GRAPHIC: GETTY IMAGES/ISTOCK/KINGWIN

Collectively intelligent

Is going it alone a model of the past? Researchers are pointing the way, increasingly relying on a new togetherness. To tackle problems such as diseases and climate change, they turn to the wisdom of crowds, citizen science observations, and even share knowledge among competitors.

The girl with the missing tooth laughs infectiously in a way that probably only six-year-olds can. But then, suddenly, as if she had just been pushed by an evil spirit, Kamiyah staggers – and falls over. Luckily, her mother is there to catch her. She is all too familiar with these mysterious fainting and paralysis attacks that strike the girl from the U.S. state of South Dakota dozens of times every day. Hundreds of kilometers away, in Maryland, the neuroscientist Andrea Meredith will see a video of Kamiyah's attacks on her iPad. She knows the symptoms well. Meredith will write an email, and ultimately she will become part of a crowdsourcing experiment which, as Meredith puts it, “has fundamentally changed this child's life, but also my life as a researcher.”



Kamiyah Morgan lives with a very rare illness that suddenly paralyzes her for short periods. The wisdom of the crowd helped to diagnose it.

Up until 2019, Meredith's professional life primarily took place in the laboratory. As a professor, she examines the exchange of potassium between cells – and how disruption to that exchange can disturb processes in the brain. It is a specialized field to which only a small number of researchers are dedicated. "In our model, we have already given a good description of genetic defects that can trigger neurological disorders, but we had hardly any idea of the real impact that this has on patients," she says.

When the researcher visited the New York Times website and by chance saw a video of Kamiyah, whose attacks look like someone pulled a plug, she was electrified: "I knew that I could now put the pieces of the puzzle together with everything that I know about the illness." Meredith got in touch with the newspaper, which, together with the Netflix streaming service, was asking the crowd online for tips on diagnosing mysterious illnesses – and thus set the ball rolling in Kamiyah's case.

Thanks to the many responses that poured in from all over the world following

an appearance in the Netflix documentary, "we became like giant antennae gathering and pooling information," Meredith says. Sufferers from all over the world reached out, networked among themselves – and with Meredith's research team. Thanks to crowdsourcing, individual people with rare illnesses turned into a critical mass with great scope for action. "Patients joined together to become medical detectives investigating their own cases. One family found a medicine that suppresses the stimuli which trigger the sudden paralysis attacks. They shared their findings on social media and were able to help other sufferers to stop those attacks almost completely," she says. Meredith has now set up an organization to take knowledge that is spread all over the world and use it for more patient-centered research. "Families, scientists and doctors can now learn together how this rare genetic defect works and what can be done to counter it," she says.

Crowdsourcing, or using swarm intelligence to solve tricky problems, is a concept that seems to fit well into a time when challenges are often too complex

for individuals alone to come up with a magic formula to solve them. Experts open themselves up in the hope that the wisdom of crowds – or one individual in that crowd – may show them the way, or at least offer them a new perspective. In the face of great challenges, the idea of joint action literally forces itself on us and offers grounds for optimism.

Competitive thinking? Passé!

The chemical industry is also facing an enormous task: the transformation to climate-friendly production. To do this, it is steering a course toward being open. In several areas, BASF has opened up its innovation practices to promote low-emission processes. Together with competitors, suppliers and customers, the company is pursuing experimental paths to develop new, sustainable technologies – for example, in processes that are still too costly and uncertain in their outcomes to be tackled alone.

This is the case with a pilot project on electrically heated steam cracker furnaces. In the future they will be used to fire the large production plants, which

PHOTO: NETFLIX/DIAGNOSIS; GRAPHIC: GETTY IMAGES/ISTOCK/KINGWIN

“
We are interested in sharing knowledge and jointly gaining new insights.”

Dr. Andrea Hauernert
Technology Manager,
BASF Petrochemicals,
Ludwigshafen, Germany



PHOTO: BASF SE; GRAPHIC: GETTY IMAGES/ISTOCK/KINGWIN



In a joint effort with SABIC and Linde, BASF is constructing the world's first demonstration plant for electrically heated steam cracker furnaces at its Ludwigshafen site in Germany.

Quantum leap

Quantum computers are seen as a key technology for the future. These new devices work with qubits. Unlike bits in "normal" computers, which can only have the value "one" or "zero," qubits can assume both states at the same time, as well as an infinite number in between. These states can be superposed and quantum entangled. As a result, the computing power of certain applications will be significantly higher – for exactly which ones is currently to be identified through intensive research. In the chemical industry, for example, it will be possible to simulate complex chemical processes where today's supercomputers are close to their limits. Companies are moving toward this new, highly complex technology by pooling their efforts. One example is the Quantum Technology and Application Consortium (QUTAC), in which leading companies from Germany have joined forces. BASF is also involved in projects like the Quantum Computing User Network (QuCUN), which aims to support companies of all sizes in entering the world of quantum computing.

are so important to the chemical industry at the beginning of the value creation process, in an environmentally friendly way. Splitting naphtha into the basic building blocks of olefins and aromatics requires temperatures of up to 850 degrees Celsius. Up to now, gas is being burned for this purpose. "This causes high CO₂ emissions, making the plant one of the top emitters in the chemical industry," says Dr. Andrea Hauernert, project lead and technology manager at BASF's Petrochemicals division. For some years, BASF has been pursuing in-depth work on the idea of powering the cracker electrically – with energy from renewables instead of natural gas. A large-scale demonstration plant, which will eliminate at least 90 percent of process emissions compared to technologies commonly used today, is due to start operation in 2023. It will be fully integrated into one of the existing steam crackers at BASF's Verbund site in Ludwigshafen, Germany.

"Initially, we will have to invest a lot," Hauernert says. And yes, she adds, BASF is taking considerable risks: "As always with a research idea, it is uncertain ▶

A crowd of Argentine citizen scientists is taking action against dangerous mosquitoes with an early-detection app.



“Users experience themselves as part of a collaborative citizen project.”

Joaquín Cochero
Biologist, Buenos Aires, Argentina



whether our idea is the right one. Will the technology ultimately be successful in the market? That too is far from clear.” One can embark on such a risky venture, she says, only “if you have like-minded allies alongside you.” To achieve this, BASF joined forces with technology partner Linde and Saudi chemicals giant SABIC – a direct competitor of the Ludwigshafen-based company – which also has many years of experience in operating steam crackers.

For BASF, the pilot project is about sharing knowledge among equals and jointly gaining new insights. “Findings from operating this plant will belong to all three partners,” Haunert says. The project received funding from the German Federal Ministry for Economic Affairs and Climate Action under its “Decarbonization in Industry” funding program. If all goes well, the first steam cracker furnaces could be switched on a large scale from gas to renewable electricity from 2030 onward. “Thanks to our close cooperation and the expertise that the three partners bring, we could be the first in the world to succeed in doing this.”

Undercover citizens hunt mosquitoes

Joaquín Cochero, too, has experienced how the work of pioneering researchers can have a broad impact thanks to networking. The young biologist from Buenos Aires is using swarm intelligence to find swarms of mosquitoes. He is an expert on the Egyptian tiger mosquito. Mosquitoes are by far the deadliest creatures in the world. They transmit pathogens for malaria, dengue fever or the Zika virus. “Here in Argentina, dengue in particular is constantly breaking out,” Cochero says. “The swarms migrate further and further southward from the tropical regions in the north. We are able to monitor this movement basically in real time, thanks to data from our Caza Mosquitos app.” To track down these problematic species so that outbreaks of infection can be nipped in the bud, the entomologist relies on a crowd of citizen scientists. They are the ones who bring the app to life that has been developed by Cochero.

“Users initially download the app out of self-interest: They want to know whether the mosquito in their house is dangerous.



The city as a real-life laboratory: In Panaji, India, women walk along roads together to build an inclusive city.

“The women’s ideas form pieces in the puzzle to make up inclusive roads.”

Bhavya Bogra
City planner in Panaji, India



From us they learn more about these creatures and their living conditions. In this way, they experience themselves as part of a collaborative project, and this motivates them to actively participate.” Thanks to their data, previously dark spots on the map of the spread of *Aedes aegypti* and others are gradually being illuminated. Cochero and his team have now made a quiet alarming observation: “As a consequence of climate change, we are seeing carriers of pathogens in more and more areas where they were not previously common,” he notes. Mosquito swarms are finding ideal breeding grounds particularly in constantly growing cities where overpopulated settlements are struggling with difficult hygiene conditions and polluted water and soil. He sees the prevention of dengue and other epidemics as a shared task. The app, which has been downloaded more than 10,000 times, is making just an initial contribution to this. “Especially in the hands of such a smartphone-oriented society as Argentina, it can be a decentralized early-warning system,” Cochero says. Moreover, it is an important tool for spreading education

and information. Schools and local and regional authorities are gradually starting to use Caza Mosquitos. “Our fight against these diseases can only succeed if administrators and policymakers work hand in hand with citizens,” Cochero concludes.

Women power inclusive urban planning

A prime example of what happens when an administration places a city’s development in the hands of its residents can be found on the other side of the world, in Panaji. The capital of the Indian state of Goa is turning into an Urban Living Lab – a real-life laboratory for urban development. On closer examination, the tourist metropolis turns out to be a city that has typical urban problems, says the young city planner Bhavya Bogra. It is plagued by traffic chaos on roads “where the needs of several community groups, most of all women, fall by the wayside.” As Bogra soon realized, this urban problem can only be untangled by collaborating with partners in a citizen-centered, bottom-up approach.

Smartphones installed on cars took more than 17,000 photos and provided detailed insights. “Most of all, however, we gained the full picture from around 30 women from all walks of life, whom we followed on the routes that they normally take. That was an excellent learning experience,” she says. The Indian women talked about curbs that were broken or too high – impossible to navigate with strollers – and about frightening areas that they have to cross in the dark.

“The women’s ideas form pieces in the puzzle to make up inclusive roads,” Bogra says. An action plan provides for well-lit roads, unobstructed and pedestrian-friendly crossings, and an emergency telephone number for women. The overall plan intends to gradually turn Panaji into an inclusive city for all of its citizens – though the coronavirus lockdowns have slowed down this process, as Bogra admits. However, nothing stops the dynamic that unfolds when the creative potential of the many is combined with expert knowledge and powerful motivation. The “good genie” of a common cause is out of the bottle. ■

A taste of progress

What culinary creations will we have melting in our mouths in the future? And how will these new varieties be able to provide improved flavor or combat climate change and waste? Breeders search for answers with decades of perseverance. We present some fruits, vegetables and other foods with special ambitions.



Onions without tears

It is enough to make you weep – but understandable, nevertheless. When onions irritate our ocular mucous membranes, they are actually merely trying to protect themselves against natural enemies. The blame for the tears rests with sulfurous ingredients known as mustard oils, which come into contact with enzymes when an onion is cut. However, its biggest natural enemy – the human being – has come up with a counterstrategy. BASF aims to stop tears in the kitchen with its Sunions® onions. The breeders of this mild type of onion have reduced most of the irritants through crossbreeding during more than 30 years of work. With every day that it is stored, this onion becomes milder – unlike others, which become more pungent over time.



Melon with a color code

Finding precisely the right moment to act is hard to do – this is true both on the stock exchange and out in the fields. Fruits are often harvested either too early or too late. This means that quality losses and food waste are inevitable. For this reason, the Galkia melon, whose seeds are sold by BASF, has had a kind of color coding bred into it. When its skin changes color from green to yellow, it is at optimum ripeness for harvesting. Consumers can then enjoy its full flavor for about another 14 days.



Mild mini-cabbage

The British breeder Tozer Seeds has been crossing kale and brussels sprouts for around 15 years. This resulted in Kalettes®, which have a slightly nutty, milder flavor. As a typical winter vegetable, these new, loose sprouts measuring up to 5 centimeters with curly, green to purple leaves are in season in Europe from November to mid-March. Their journey from the pan to the plate is both quick and energy-efficient: They are cooked in just four minutes.



Wines for all weathers

“Vinnovation” is the response to climate change from the French wine-growing region of Bordeaux. In order to preserve the Bordeaux style in spite of rising temperatures, longer heatwaves, and shorter ripening times, the winemakers of Bordeaux spent 10 years researching new wine varieties – until the French Ministry of Agriculture finally approved a total of six new red and white varieties in 2021. According to the revised guidelines for controlled designations of origin (Appellation d’Origine Contrôlée, AOC), they are identified as “new varieties of interest for adapting to climate change.” Their proportion in a blend is limited to a maximum of 10 percent.



Waste-free cauliflower

Everything is edible: iStem®, the new cauliflower breed from Syngenta, is available on a stem. The narrow stalk, which is more than 10 centimeters long, is said to taste sweet and nutty. Accordingly, it ends up in people’s stomachs along with the cauliflower head, instead of in the garbage. As a result, the breed helps to counter food waste, because the traditional, thicker stalk is all too often discarded. One more bonus, especially for farmers, is that this cauliflower repeatedly produces new side shoots with florets, meaning it is very productive.



Resource-friendly lab coffee

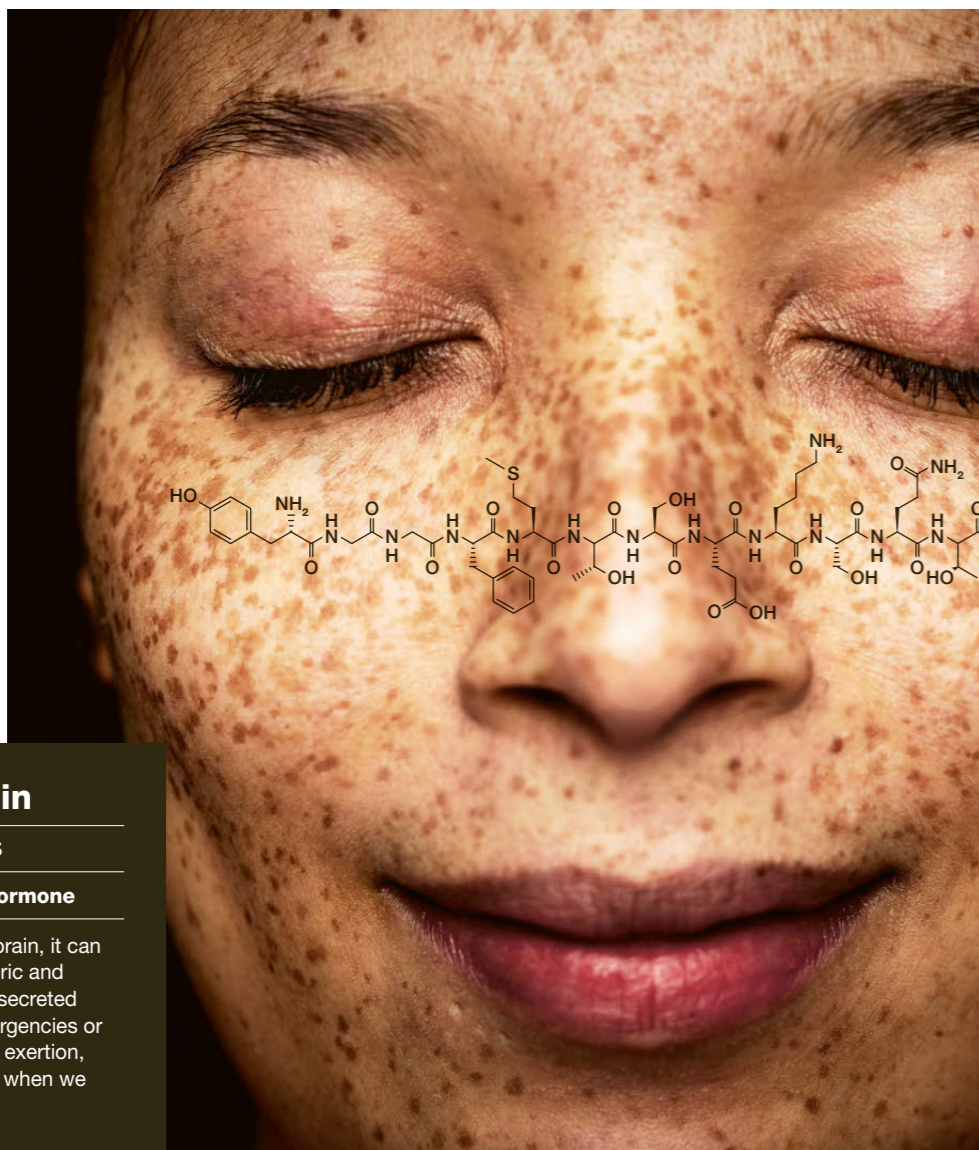
In 2021, scientists at the VTT Technical Research Centre of Finland created coffee in a laboratory for the first time. To do this, the research team bred cells from coffee plants and produced biomass from that – a process similar to the one used for meat from a petri dish. This mass is then dried and roasted to make coffee powder. The resource-friendly laboratory coffee could come onto the market by 2030.



PHOTOS: BASF/ABEL F. ROS/QUARTALES; BASF/GOLDENINSIGHTS; GETTY IMAGES/ISTOCKPHOTOS; VTT; GETTY IMAGES/BLOOMBERG PICTURE ALLIANCE/IMAGE BROKER/WS/ MONICA GUIMM

Chemistry of feelings

They seem to have us completely under control, can plunge us into inner chaos or let us feel like we are floating on cloud nine. We are talking about hormones. In words and images, we show what lies behind our great emotions.



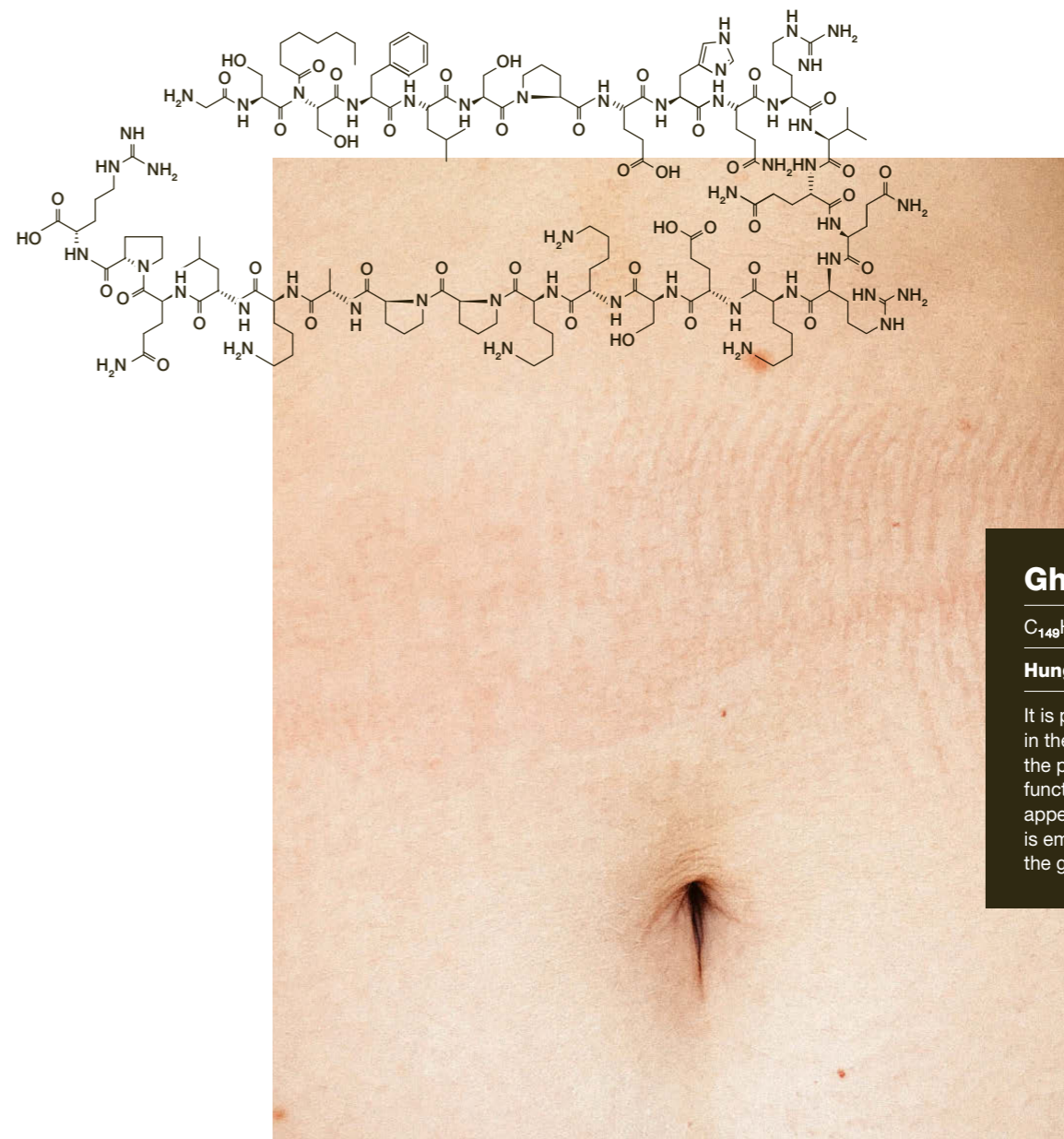
Endorphin

$C_{77}H_{120}N_{18}O_{26}S$

Good mood hormone

Formed in the brain, it can make us euphoric and ease pain. It is secreted not only in emergencies or during physical exertion, but also simply when we laugh or sing.

PHOTO: GETTY IMAGES / JUSTIN LAMBERT; GRAPHIC: ASCS / JULIA ZIMMERMANN



Ghrelin

$C_{149}H_{249}N_{47}O_{42}$

Hunger hormone

It is produced mainly in the stomach lining and the pancreas. One of its functions is to stimulate appetite when our stomach is empty. After a meal, the ghrelin level drops again.

PHOTO: STOCKSY / KAYLA JOHNSON; GRAPHIC: ASCS / JULIA ZIMMERMANN

H

ungry? Tired? On a high? We would not have any of these feelings without hormones. "Hormones are something like the background music to our existence – an atmosphere that is always there," says German neuroscientist Dr. Franca Parianen, who focuses on hormonal activity as a science slammer – in bars, at medical congresses, and as the winner of the German Neurological Society's neuro slam. "They are part of us, and they define us as individuals."

The biochemical transmitters determine what makes us anxious or feel good, but also when we

become sleepy or highly motivated. Our hormonal system is part of a sophisticated mechanism that makes our body work. "They can trigger complex processes," Parianen says. "Short-term reactions like a moment of shock, but also long-term programs like puberty." Hormones are composed mainly of proteins or lipids, which are basic components of our organism. "But there is not just one single chemical structure – some hormones are very complicated, while others are very simple," Parianen says.

The brain takes the first step in hormone production. It evaluates incoming information and sends signals to the producing organs, such as the ▶

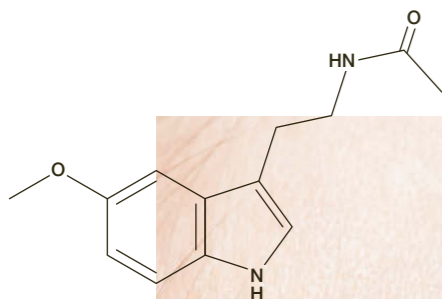
thyroid, pancreas and adrenal glands. The transmitters pass through the bloodstream to their intended destinations, where they dock with the cells that are waiting for them. There they trigger the reactions intended by the brain – for example, short-term reactions in metabolism and circulation, or longer-term ones in growth or sexuality. They cause our emotions to ebb and flow. In other words, hormones are the chemistry of our feelings.

All in your head?

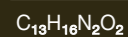
“Perhaps the simplest and earliest examples, the first demonstrations of body-to-brain communication, are the steroid hormones that regulate reproductive function: estrogens and androgens like testosterone,” says

Dr. Donald Pfaff, Emeritus Professor of Neurobiology and Behavior at The Rockefeller University in New York, United States. Sexual hormones play a major role in shaping our brain even before birth. Early in our life, another hormone immediately gets involved: oxytocin, also popularly known as the “cuddle hormone.” It is not only responsible for the strong bond between newborns and their parents, but is also the glue for close social relationships during our lifetimes.

The sense of well-being extends to other areas of life. Oxytocin reduces stress, makes us less aggressive and consequently more compassionate. And this doesn't just apply to human beings. Researchers at the University of Minnesota, ▶



Melatonin



Sleep hormone

Regulates the day/night rhythm. Produced in the diencephalon when it is dark outside, it promotes sleep. Accordingly, its concentration in the blood during the night peaks at a level that is roughly ten times higher than during the day. As soon as daylight falls onto the eyes, the supply is sharply reduced – but this also happens with a high level of blue light. That is why scrolling on a smartphone late in the evening can prevent us from sleeping – a no-go in sleep hygiene, and with good reason.



Oxytocin



Cuddle hormone

Translated from ancient Greek, the name means “fast birth,” because it starts contractions. In addition, oxytocin, which is formed in the brain, is regarded as a social cement, because it strengthens relationships – whether in terms of love, sex or social contacts.

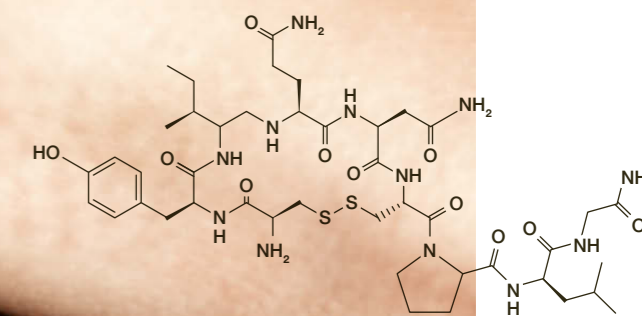


PHOTO: GETTY IMAGES / MOMENT / ROC CANALS; GRAPHIC: ASCS / JULIA ZIMMERMANN

PHOTO: GETTY IMAGES / E+/RYAN J. LANE; GRAPHIC: ASCS / JULIA ZIMMERMANN

United States, sprayed the bonding hormone into the noses of African lions. Afterwards, the predatory cats were much more relaxed and tolerated more closeness from other members of their species. An oxytocin effect can also be observed between human beings and their pets. Japanese scientists gave owners half an hour to talk to their dogs and to cuddle them with intensive eye contact. Their subsequent oxytocin levels were significantly higher – and this applied to both the two-legged and the four-legged participants.

This means that our feelings are determined to a decisive extent by those transmitters. “It is hard to think of a hormone that is not influential on our emotions. Of course, only some of these are direct effects and there is a plethora of indirect ones,” Pfaff says. “Every hormone has a basic function, but what are

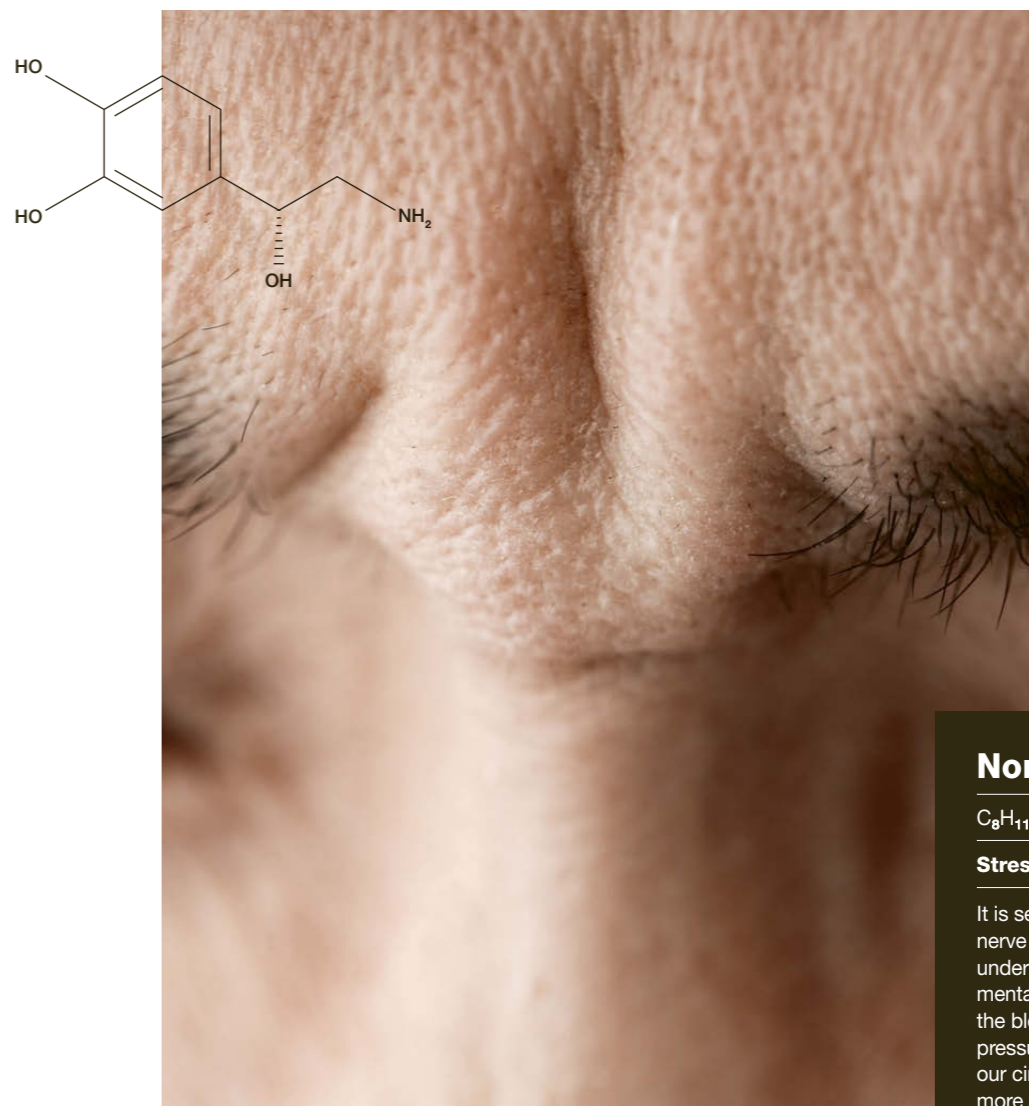
known as epigenetic effects make way for individual experiences to influence how hormone effects work out.” This also explains why human beings handle stress in different ways. First, a standard program runs like this: Adrenaline and noradrenaline become active. Our heart beats faster, we breathe more deeply, our senses become heightened, and bodily functions such as hunger, thirst or pain close down. We become instantly ready for action. “Our stress response is actually there as a survival mechanism,” Parianen explains. Today, though, even things like an important presentation, bungee jumping, or Sunday drivers on the roads can send our adrenaline levels through the roof.

When we are extremely agitated, this usually subsides again quite quickly, thanks to the programming of our hormones. However, if we constantly carry on like that, long-term stress is just around the corner. For our body, this means that the adrenal glands produce increased amounts of cortisol. That hormone can actually be good for us, as it makes us less sensitive to pain, for example, and inhibits inflammation. In the long term, however, a high cortisol level weakens the immune system. “Chronically secreted stress hormones are not good for the brain and can actually have an impact on its structure,” Parianen says.

Don't stress about stress

The good news is that no one is completely at the mercy of their hormones, because “the interaction between hormones and behavior is bidirectional. Hormones can influence behavior, and behavior can sometimes influence hormone concentration,” says Professor Randy J. Nelson, a neuroscientist at West Virginia University, United States. With cortisol, this effect can actually be measured – specifically in hair, because it is deposited there. The German Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, and the Research Group for Social Neuroscience of the Max Planck Society, Berlin, took a closer look at this in a study. Test subjects each spent half an hour, six days a week, performing a mental training exercise that was intended, in particular, to strengthen their mindfulness and empathy. No stress about stress – the first effects were visible after just three months, and after six months their cortisol levels were on average 25 percent lower. Even in acute stress situations, such training exercises help people to keep a cool head.

“Interestingly, the things that stress us are often the same as those that motivate us positively,” Parianen notes. What is the difference? In particular, the level of perceived control. If we feel a loss of control, stress gains the upper hand. However, if we



Noradrenalin

$C_8H_{11}NO_3$

Stress hormone

It is secreted, especially by nerve cells, when we are under severe physical and mental pressure. It constricts the blood vessels, our blood pressure rises, and so does our circulation. We become more alert and focused. Too much of it, however, can make us restless or anxious.

Emotional intelligence

How can we understand the world of our feelings? And how do we deal with the emotions of others? The key is emotional intelligence.



Dealing with ups and downs

Who is not familiar with the emotional highs and lows of life? However, it is not conducive to good coexistence with others for us to put every single emotion on display unfiltered. The way we handle our emotions is an expression of our emotional intelligence.



Perceiving emotions

Another feature that distinguishes emotionally intelligent people: They recognize how others are feeling and can respond appropriately.



Success through empathy

This ability is also important in the world of work. Emotionally intelligent managers can identify and resolve conflicts faster, for example. They have greater success in motivating their teams.



Building blocks of emotional intelligence

The concept was popularized by the book “Emotional Intelligence” by U.S. author Daniel Goleman, published in 1995. According to Goleman, emotional intelligence consists of four building blocks: self-awareness, self-management, social awareness and relationship management.

have control, situations which are a little stimulating and tricky are good for us. This is mainly down to dopamine and serotonin. First, dopamine enhances our motivation. If the dopamine level is balanced, we find it easy to tackle things and pursue our goals. This does not have to mean starting with a triathlon – gardening, cooking, or learning a language can also provide a sense of achievement. The brain then releases serotonin. This transmitter is considered the happy hormone. However, it can do a lot more than lift your mood. Serotonin regulates hunger and body temperature, among other things. It is also part of our biological clock.

Daylight and sunlight boost serotonin production. When it starts to get dark, our body converts serotonin into melatonin and we become tired. During the night, the melatonin level falls, while the cortisol level rises and makes us alert. Modern life can disrupt this sophisticated mechanism, with not much daylight, but brightly lit screens until late evening. This confuses our day/night rhythm. But Parianen is reassuring: “The crazy thing is that our sophisticated hormonal system is, on the one hand, so complex at the biological level, but on the other hand so uncomplicated that one can say movement, relaxation and sunlight are simply good for us.” ■



1 A flower to the rescue

Philippines A huge water lily from the Amazon is the model for this locally developed concept. Thanks to the ribbed veins on its underside, the aquatic plant can bear a weight without sinking. According to an idea from Re-Leaf, this design is to be reproduced on the bottom of life rafts, working like a small air pocket to provide buoyancy as soon as it comes into contact with water. This will enable people in Tumana, a suburb of Manila, to better withstand floods and torrents in the future. During calm weather conditions, one idea is to convert this double-layer, modular platform into a park bench.

bit.ly/re-leaf-raft



Follow nature's example

Creating air-conditioning like termites or using water lilies to save people from floods – animals and plants often show us how to do things better. Here are some inventions inspired by ingenious flora and fauna around the world.



2 Ostrich-inspired running robot

Germany, United States A team from the Max Planck Institute for Intelligent Systems and the University of California, Irvine, has designed robotic legs that are especially energy-efficient – inspired by the flightless but speedy ostrich. Unlike humans, running ostriches fold their feet back when they pull their legs up toward their bodies. The BirdBot does this, too, thanks to a mechanical muscle-tendon cable between

the foot and the leg joint. The robotic legs need only two motors for running – one on the hip joint and one on the knee joint. The robot can stand and lift its leg without a motor. As a result, the BirdBot is expected to need only one-quarter of the energy required by previous walking robots. It has already passed the treadmill test.

bit.ly/birdbot

PHOTOS: PICTURE ALLIANCE/IMAGEBROKER, BIOMIMICRY.ORG, PICTURE ALLIANCE/DESIGN PICS, DLG WPI-IS AND UC IRVINE

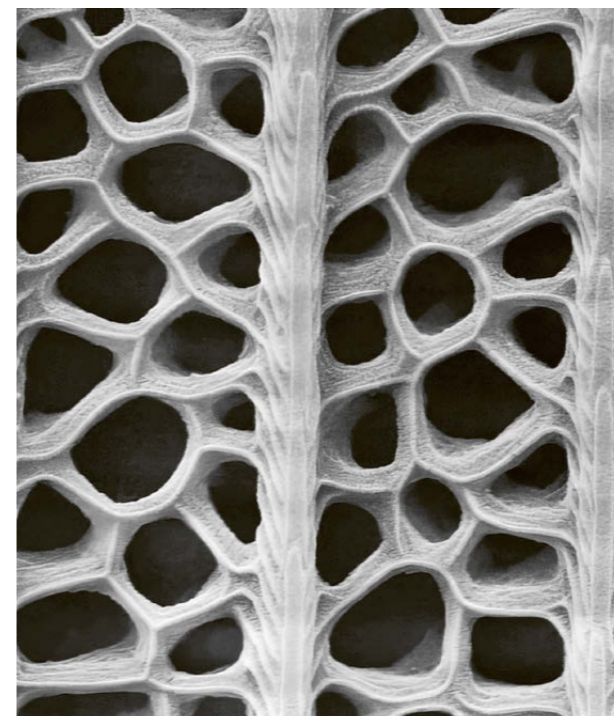


3 Cool like termites

Zimbabwe In Africa, termites are masters of air-conditioning. They build sealable tunnels through which cool air is sucked up from the depths of their mound and heat can escape. This smart ventilation principle enables the tiny insects to prevent extreme temperature fluctuations inside their nest. The Eastgate Centre in Harare, opened in 1996, was probably the world's first human-made building to use this termite trick. Warmer air rises to the top, causing cooler air to flow in from below to replace it. This cooler air is channeled into spaces in the floor, and from there into the offices. Warmed by the heat of the day, the air is channeled upward by a system of pipes – a really “cool” effect.

bit.ly/climatetermites

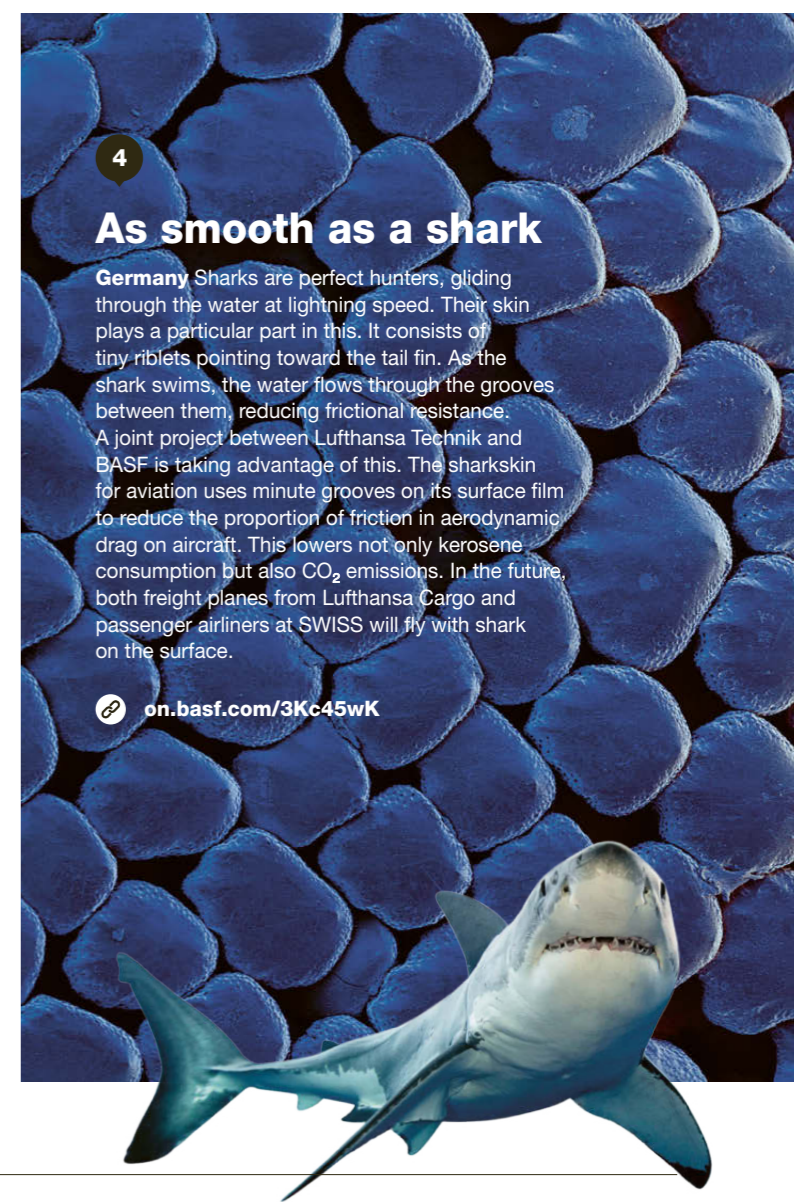
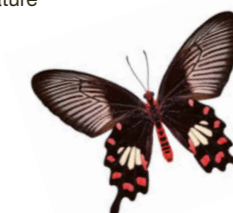
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5 Energizing like a butterfly

Germany, United States Scientists at the Karlsruhe Institute of Technology and the California Institute of Technology have replicated the nanostructures of pitch-black butterfly wings on silicon solar cells. The idea is that these thin, material-saving cells will be able to absorb up to 200 percent more light and become serious competition for conventional crystalline solar cells. The original winged source of inspiration can almost completely absorb sunlight by means of minute holes in its wings and regulate its body temperature in this way.

bit.ly/solarbutterfly



4 As smooth as a shark

Germany Sharks are perfect hunters, gliding through the water at lightning speed. Their skin plays a particular part in this. It consists of tiny riblets pointing toward the tail fin. As the shark swims, the water flows through the grooves between them, reducing frictional resistance. A joint project between Lufthansa Technik and BASF is taking advantage of this. The sharkskin for aviation uses minute grooves on its surface film to reduce the proportion of friction in aerodynamic drag on aircraft. This lowers not only kerosene consumption but also CO₂ emissions. In the future, both freight planes from Lufthansa Cargo and passenger airliners at SWISS will fly with shark on the surface.

on.basf.com/3Kc45wK

Sharing

A cow among us

In cow-sharing, the meat of a cow is divided up completely among various buyers. It is not slaughtered until the whole animal has been sold, so that no meat is wasted. An age-old principle has thus reached the start-up era.



PHOTO: GETTY IMAGES/EYEEM/NIKA KUTSIA

Minimizing

Capsule combos

The capsule wardrobe consists of basics that can be combined in a wide variety of ways.

One approach to what this can look like is presented by slow-fashion blogger Candice M. Tay at #capsuleconversations.

If you are unsure about color combinations, you can follow the example of former U.S. President Barack Obama and rely on just two colors – in his case, dark blue and grey.



Enough is enough

Minimalists – aren't they the ones with white, empty rooms? Yes and no. In addition to being a design style, voluntary simplicity is a social movement and a guide to sustainable, conscious consumption. Our author endeavors to find out how much is enough.

PHOTO: GETTY IMAGES/MOMENT/ALEXANDR DUBYNIN

My journey toward minimalism and more sustainability begins with a move within the German city of Cologne and the realization that

I am a hunter-gatherer – just like so many people in affluent societies. According to the L.A. Times, an average U.S. household owns around 300,000 items, and the Neue Zürcher Zeitung estimates that each European hoards about 10,000 objects – numbers that supporters of a minimalist lifestyle like to cite as a deterrent, although there is no actual evidence for them. I start counting what I have in my home, but soon give up – I can't keep up with the unofficial competition among minimalists on the internet to get down to the magic figure of 100 anyway. ▶

“Less is more” is their credo, which also embraces the idea of a more sustainable lifestyle. Sounds good at first, but what does it actually look like? When I search the term “minimalism” on the internet, I find thousands of images of airy, empty, immaculate white rooms. I also come across “The Minimalists” – real names Joshua Fields Millburn and Ryan Nicodemus – who are trying to help millions of people to lead more meaningful lives with fewer possessions. The two Americans spread their message by all available channels – they blog, make podcasts, write books, and deliver enthusiastic speeches.

The empty desire for more

What does science say about the trend toward minimalism? Where does the desire for voluntary simplicity actually come from? I put these questions to Joshua Hook, Professor of Psychology at the University of North Texas, United States. He has conducted a review study examining the relationship between minimalism, voluntary simplicity, and well-being. A few hours later, I receive his response: “At least here in the States, there is often an urge to have more – more money, bigger houses, and so on. But I have the impression that this urge often feels empty,” the psychology professor writes. This is also true in Cologne, I think.

“**Studies show a generally positive relationship between minimalism and well-being.**”

Professor Joshua Hook
University of North Texas,
United States

Renting

Furniture as needed

Using furniture without owning it: IKEA has been doing this since 2021 in Spain and Poland, for example. In those countries, the Swedish company is trialing a furniture subscription model for corporate customers, repairing and maintaining furniture so that it can be reused as often as possible. This furniture service will soon also be available to private customers.



PHOTO: IKEA

Too many things, too many commitments, too much information. During the pandemic, many people in affluent societies realized how many things in their lives were “too much,” and the lockdown marked the start of the great clear-out. For some, this was a way of passing the time, for others it was necessity – they needed more space because suddenly all family members were constantly at home. It strikes me that this lockdown minimalism is merely the reaction to a problem.

Video call to Richard Watson, author, lecturer, and futurist-in-residence at the Cambridge Judge Business School, England. I reach him in his summer house. “All sorts of stuff in here, as you can see,” Watson, born in 1961, calls cheerfully to the camera. For him, the movement from more to less is “definitely a trend for people in prosperous industrialized nations,

for a rather young and urban target group.” They are a minority. The countertrend is known as maximalism. “The accumulation of objects as a status symbol is particularly noticeable in emerging markets,” he says. And not only there. In rich countries, too, many people simply want to be able to treat themselves. Although car-sharing rates in Germany, for example, continued to rise significantly in 2021, one in four new registrations was for a gas-guzzling SUV.

For the minimalists Millburn and Nicodemus, the “less is more” lifestyle is paying off. As they put it, not only have they changed their own lives for the better, but also their followers write posts reporting feelings of happiness, greater satisfaction, and better personal relationships. These are big promises, but there is not yet much evidence of all

this in Cologne. What does science say? I ask Professor Hook in Denton, Texas and receive a prompt reply: The studies examined reveal “a generally positive relationship between minimalism and well-being.” However, he points out that almost all the studies were correlative. In other words, just because there is a strong connection, that does not mean there is a clear cause-and-effect relationship. “For this reason, we cannot say with certainty that minimalism boosts well-being – merely that there is a positive connection between them,” the academic adds, announcing further research on the subject. I shall probably have to be patient, so I start an experiment on myself.

Do I really need it?

It is time for a practical test and a packing party in the style of “The Minimalists.” ▶



PHOTOS: GETTY IMAGES/STONE/THOMAS M. BARWICK INC

Digital detox

Phones off

Are you a digital junkie, constantly pulling out your smartphone to take photos and post and like things? Pay attention to these tips from U.S. bestselling author Cal Newport: Leave your smartphone at home. Do not dish out likes or write comments on social media. Open your messaging apps only twice a day, at specific times. Also, consider first how to make meaningful use of the time you are going to save.

It works like this: You act like you are planning to move house, and pack all your belongings in moving boxes, label everything neatly, and then unpack only those things that you absolutely need. For everything else, the rule is: donate, sell or recycle. However, the minimalists recommend that action should be preceded by reflection. I can only answer the question “What should my apartment look like?” when I know what my life should look like. I was not at all prepared for such deep questions, but never mind. In my case, the answer is: less material ballast and more time for trips into nature. As I pack for my real move, I first make quick progress, because at first I pack only things that I will immediately need in the new apartment: a pot, plates, a towel and similar essentials. Then it gets tough. The drawers are full of yellowed

“**It is more important to have access to things than to own them, and if you share, you save resources.**”

Richard Watson
Futurist-in-Residence,
Cambridge Judge Business School,
England

concert tickets, the closet is piled high with T-shirts, and in the kitchen cupboards I discover as many as six opened packets of paprika. I decide not even to think about the cellar for the time being.

Then, while I’m still in the process of thoroughly sorting and disposing, I suddenly reach for my smartphone and procrastinate. While I scroll through social media, ads are constantly popping up for products that make use of the motto of minimalism. The search for minimalists and their ideas have clearly encouraged my algorithms to intervene in my decluttering and to keep making purchase recommendations.

The business of minimalism

The less-is-more principle has obviously penetrated the product world. Watson answers the question of whether companies, too, can pursue a minimalist philosophy with a clear “Yes,” and cites the example of Muji. This Japanese company enjoys global success with its functionally created products and their minimalistic design. It now also offers micro houses. Tiny houses as a product range are something I’ve already come across in my home region of North Rhine-Westphalia, where the Containerwerk company gives a second lease of life to decommissioned shipping containers – offering high-quality living conditions in a small space.

The idea of minimalism is linked not only to the tiny house movement but also to the mega-issue of sustainability, Watson believes. As these mini houses do not have much space, you have to limit yourself to the essentials. In addition, it is usually true to say that the less living space a person occupies, the lower their CO₂ emissions will be.

“You’ll own nothing and be happy,” it says in the video “Eight predictions for the world in 2030,” which was produced for the 2017 World Economic Forum. I am a long way from that, I think, as I throw the concert tickets into my paper waste. The quotation comes from Danish member of parliament Ida Auken, who foresees a future of sharing. Watson similarly says that, when it comes to sustainability, minimalism and the sharing culture could and should come together. “It is more

Sharing

Common ground

Desperately seeking a room? The “home in return for help” approach could be the answer. The elderly or families receive help in the home and share their apartment, which students, for example, can use cheaply in return.

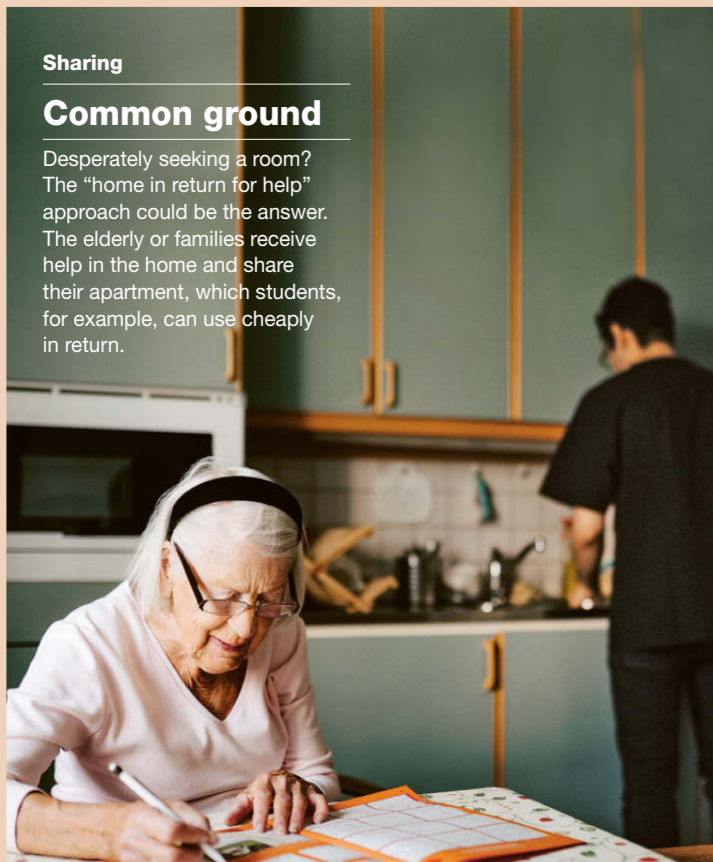


PHOTO: GETTY IMAGES / MASKOT



important to have access to something than to own it, and if you share things, you consume fewer resources,” he says. Especially for young people, Watson says, it is normal to borrow what you need as you need it.

My conclusion about minimalism: Even though my new apartment looks only semi-minimalist, I have gained a lot by holding a packing party to do my clear-out and thinking hard about which things I really need. However, I am still miles away from the target of 100 items. Meanwhile, I am consoled by Millburn and Nicodemus. In their words, it is not about “owning as little as possible, but simply owning the right things – and what is right is something that each person has to find out for themselves.” I decide to continue working on myself and my non-ownership, and I am eager

to see whether the minimalism movement will endure. Futurist Watson in Cambridge, anyhow, is frowning in front of his laptop and issuing a warning in view of an impending global recession: “I really hope minimalism will continue, but if the economy collapses, that trend might disappear out of the window!” This is because, if you suddenly have to rein yourself in as a result of economic necessity, a lifestyle of deliberately chosen frugality will not work for you anymore. Psychologist Joshua Hook in northern Texas is more optimistic about it: “If individuals become aware of the positive impact of minimalism, I believe that this trend is definitely sustainable,” he says. ■



Eva Scharmann has made moving house into a minimalism experiment.

Tiny houses

Small space living

The Containerwerk company gives a second lease of life to decommissioned shipping containers as minimalistic, high-quality and affordable living-space modules. To make them energy-efficient and safe – especially from fire – a form of insulation that has now been patented was developed, using Elastopor®, a polyurethane foam from BASF. The thin insulating layer saves space and complies with relevant energy-efficiency regulations. From this spring, the minimalistic modules will also be used for sustainable hotels.

Breaking the chains?

With the coronavirus pandemic, geopolitical tensions and climate change exposing weaknesses in today's international supply chains, Creating Chemistry asked experts whether recent events are signs that globalization is reaching the end of the road.

It's easy to underestimate the modern world's reliance on global supply chains. Until they break. For many people, the past three years have been the first time in their lives that they have faced shortages of materials, manufactured goods and energy. Now governments, companies and individuals are asking whether we have become too reliant on a fragile web of trading relationships that stretches across the world. Should industries be adapting and strengthening their global supply chains? Or should they replace them entirely? And what role does sustainability play? We asked four experts to assess the state of globalization today. A historian explains that trade has supported domestic and international stability for centuries, but that those trading relationships have always been vulnerable to political and social change. A supply chain engineer explains how technology has the potential to improve global supply chains, but also to supplant them. A risk expert highlights the ways leading businesses are building new resilience into their supply chains. Finally, BASF's Head of Corporate Sustainability Relations describes the company's efforts to build and maintain equitable and sustainable supply networks in the chemicals industry and beyond.

PHOTO: GETTY IMAGES / MOMENT/KARL HENDON

The historian

Globalization remains vulnerable to political and social changes

The future of globalization is currently in the spotlight. What were its roots?

The roots of globalization reach as far back as the migration of modern humans from Africa. Ice age burial sites with artifacts from distant places speak of our innate fascination with the distant and alien. Globalization, in the modern sense, can be traced to 1206, with the start of the violent expansion of the Mongol Empire linking polities and economies across the Eurasian landmass. Subsequent waves of globalization waves were all the result of the competitive pursuit of imperial authority and status.

What were the main factors driving globalization in the past?

Broadly, political success in Europe was defined by the emulation of the legendary might of the Roman Empire. This was how political legitimacy was sustained and, from this, stability and prosperity. The Dutch and the English created modern-looking trading empires in the 17th century. Colonial agriculture, as a key pillar, was more about serving the European appetite for luxuries, such as coffee or tobacco, than about feeding hungry populations. Yet those were relatively insignificant imitators of the great land-based and militarized empires such as the Mughal Empires in Asia or the France of Louis XIV. Only in the 18th century did trade and financial strength begin to acquire political value in its own right, as the British Empire shows.

How did global supply chains as we know them evolve and develop?

Overland trade routes are, of course, timeless. What we recognize today as global trade, however, started with the export of European maritime technology. In the early 16th century, the Portuguese in their robust sailing ships offered transport services – at gunpoint – and integrated into existing Asian trade networks.

What factors led to the decline of these global trading relationships?

There are countless reasons, some of them environmental. Sometimes changing technology altered supply and demand to great effect. Mostly, however, decline was linked to political reactions. If an economic relationship was unequal, the seeds of its long-term decline were already sown. The 1773 Boston Tea Party is a famous example of a deliberate disruption of an imperial trading system across three continents.

What parallels can we draw between today's globalized economies and earlier ones?

Empires and trade have always served domestic consumption, building internal stability as well as international reputation. That is a parallel that should not be overlooked. Globalization remains vulnerable to political and social changes, and it offers precious little protection to economic interests from the possibility of war.

What lessons can today's world learn from the history of globalization?

Perhaps the greatest lesson from history is that globalization is not necessarily a force for good. The most successful governments or states will make it one, however, by recognizing and addressing the interests of the regions and people they do business with.

Dr. Alan James

is a Fellow of the Institute of Advanced Study in Paris, France, and Reader in International History, at King's College London, England. His research interests are in the changing strategic context of the early modern period and the origins of modern states, empires and warfare.



PHOTO: IAS, PARIS; ILLUSTRATION: ASCS/CLARA PHILIPPZIG

The supply chain designer

New technologies may drive better global coordination

What does an ideally engineered supply chain look like?

An ideally engineered supply chain is one in which supply and demand are well-balanced, and where the levels of responsiveness needed from production provide the necessary agility to handle fluctuations in demand. In the pharmaceutical sector, for example, U.S. company Johnson & Johnson has been a standout in these terms. It has created Digital Lighthouses that use industrial digital technologies to boost productivity, increase sustainability and improve customer experience.

Is there a patent formula for a resilient supply chain?

It depends on the sector. Commodity supply chains need to be efficient, while essential industries – such as food and pharmaceuticals – need resilience. The longer the supply chain, the more fragile it can be. Where demand is volatile, it is very important to be connected. A game-changer in being responsive to customer needs is the interrelationship between production technology and the supply chain. If products are made locally on 3D printers rather than on a high-speed production line in a low-cost country, the consumer is able to personalize goods that can be produced to order. And because production is local, the supply chain is more flexible, efficient and resilient. Take Dutch company Signify, which is using this approach to create customized lighting solutions for its customers.

How else can technology help improve the resilience of supply chains?

New technologies may drive better global coordination. For example, modular factories that use new technologies such as industrial digital technologies can allow manufacturers to move production closer to user markets, as and when needed. Technology also gives companies more data to help them forecast demand. The pharmaceutical industry especially can have very long, tiered – and therefore fragile – supply chains. Advances in technology might help a pharma company take tiers out of its supply chain. Plus, digital technologies can help late customization. Patient information on medicines could be delivered via QR codes or video, as opposed to physical written leaflets travelling along the supply chain.

What matters more: where things are made, or how they are made?

Both are important. We are currently seeing many global tensions – between Russia and Ukraine, the U.S. and China, or the UK and Europe – so geographic proximity increasingly matters as restrictions on trade increase. Companies were once primarily drawn to low-cost manufacturing centers. Now they have other considerations, also driven by changing consumer demands, such as responsiveness, resilience, and concerns about the environment and human rights.

How will the reinvention of supply chains reshape the world's economies?

I think the current form of globalization has peaked and that the world's low-cost manufacturing centers will lose their dominance. This will rejuvenate manufacturing in industrial countries through selective reshoring or near-shoring, while China will need to stimulate greater internal consumption for the goods it produces.

Dr. Jagjit Singh Srani

is Director of Research and Head of the Centre for International Manufacturing, Institute for Manufacturing, University of Cambridge, England. He is also Co-Chair of the World Economic Forum Council on the Future of Advanced Manufacturing and Production and has firsthand experience as a supply chain director and executive manager at Unilever.



PHOTO: UNIVERSITY OF CAMBRIDGE

The risk expert

Risk and opportunity are different sides of the same coin

Which supply chain risks are the biggest priorities right now?

Supply chains continue to come under pressure on all fronts. The past few years have seen supply chain disruption largely driven by the pandemic. That also led to labor shortages in low-paid sectors, and a change in consumer purchasing patterns. Now the Russian invasion of Ukraine is further worsening an already very tense situation. On top of this, global warming is as acute as ever, and, together with human rights and environmental issues, impacting supply chain strategies.

How can companies manage and mitigate these risks?

Businesses need to make their supply chains more robust and resilient against various disruption and shock scenarios. Many companies are rethinking their supply chain strategies and partially reversing the trend of lean, low-cost and just-in-time. Some are expanding their inventories, ordering materials earlier, and are looking to add suppliers in other locations to become less reliant on any single source. In the current geopolitical environment, friend-shoring is a trend, with companies reshaping global supply chains through allies.

Will this drive a shift from global to regional or local supply chains?

There is no black and white approach. If a company moves its production closer to its home base, costs may increase as domestic labor is often more expensive,

leading to higher prices for consumers. On the other hand, a regional, near-shored supply chain would accelerate shipments and reduce transit times, and mean less cash tied up in inventory.

What place do global supply chains still hold in a risky, volatile world?

Multinational companies are here to stay and so are globalized supply chains. Companies can take measures to reduce risk by ensuring they keep abreast of changes in the world, including geopolitical ones, and by making their business and supply chain strategies variable. This requires a very agile approach. Best practices emerge if you continuously test and evolve your plans for likely scenarios and apply what you have learned from the events of the past few years.

Does effective risk management compromise growth or profitability?

From my perspective, it's the other way round. Resilience and effective risk management are prerequisites of growth and profitability as they enable a company to overcome crises, prevent large losses and protect its balance sheet.

Do today's emerging risks also create opportunities for businesses?

Risk and opportunity are different sides of the same coin. Just look at climate change. Global warming creates many risks for business, such as physical damage due to

more frequent extreme weather events and natural catastrophes, legal and regulatory risks, and transformation risks for their business models and product pipelines. On the other hand, there is an equal number of opportunities for business growth, breakthrough innovation, improved competitiveness, or stronger reputation if companies embark on the transformation towards net zero.

Michele Williams

is Global Head of Risk Consulting at Allianz Global Corporate & Specialty. Her work involves providing a range of risk consulting services to corporate customers, as well as advising underwriters on risk issues.

PHOTO: ALLIANZ; ILLUSTRATION: ASCS/CLARA PHILIPPZIG

The sustainability specialist

Sustainability will be a precondition for staying in business

What makes a supply chain sustainable?

When sourcing materials and processing them, a business must think about the impact it has. Economic and even ecological impacts, such as on landscape, biodiversity or carbon footprint, are somewhat easier to address on the basis of existing standards than social impacts, such as on values and human rights. These need global societal alignment and governance, as in the UN Global Compact, which BASF co-founded. This calls on companies to align strategies and operations, also with a view to human rights and corruption. Translating international standards into business practice is key and an integral part of our work at BASF.

Why are sustainable supply chains so important to BASF?

Chemistry is part of the solution to environmental and social challenges, but it's also part of the problem. Our processes are still too intensive in terms of fossil energy and CO₂ emissions. Besides driving innovative technologies, it's important to properly manage input and output into our chains to sustainably develop our products and services. Also, we see a growing demand for sustainable products. Soon sustainability will be a precondition for staying in business.

How far does BASF's responsibility go along its value chains?

We aim to produce as close as we can to the end-customer. And it is about

transparency. We are constantly screening our chains – which aren't really chains but networks of interactions with suppliers and customers – to identify sustainability impacts. Our Supplier CO₂ Management Program, for example, aims to make the carbon footprints of all our suppliers transparent. With more than 70,000 suppliers, that's a big task. We are also training our suppliers and guiding our customers. Beyond that, it is all about alliances and partnerships to live up to our corporate responsibility.

One important chain for BASF is the battery value chain. What are sustainability challenges and how can transparency succeed?

Batteries play a major role in powering sustainable developments such as electric vehicles. That is good news for the climate, but not necessarily for those living in areas where material for batteries is sourced. People and land can suffer from environmental impacts, and child labor is an issue in some countries. In 2017, BASF co-founded the Global Battery Alliance (GBA) to address these issues. It's a multi-stakeholder alliance that includes businesses, governments, NGOs and civil society. Within the GBA we are working on standards and tools to make this value chain socially, environmentally and economically sustainable, as well as innovative. As a flagship initiative, we are developing rulebooks for a "battery passport," based on the digitalization of data. It will show the

state of the battery regarding several sustainability criteria. We will start with the most critical ones: the social aspect of child labor and the environmental aspect of greenhouse gas emissions.

How can we overcome challenges in building sustainable supply chains?

Acknowledging the complexity of supply chains and having proper management and due diligence processes in place. Understanding that ESG environmental, social and governance aspects need to be addressed in alliances with partners and stakeholders. Recognizing that we – in business, civil society and governments – need to do that together.

Thorsten Pinkepank

is Head of Corporate Sustainability Relations at BASF. He is Chairman of the UN Global Compact Network Germany, holds various positions in sustainability business networks and serves on the Board of Directors of the Global Battery Alliance.

Turning junk into jobs

Discarded bottles, plastic bags and food cartons – piles of garbage are a huge problem on the streets of Lagos, Nigeria. The city generates around 5 million metric tons of waste every year, but only 70 percent of it is collected by authorities. Wecyclers has built a rewards-for-recycling program, enabling people in low-income communities across the Lagos metropolis to capture value from recyclable waste.

Getting the waste off the streets: When Wecyclers was founded in 2012, it collected recyclables from a network of households and communities by bike. As the business has grown, motorized tricycles, vans and trucks were added to the fleet. People get points for every kilogram of material they provide, which they can swap for cash rewards. Subscribers can use a mobile app to request a pickup, and to track the points they have earned.



PHOTOS: NYANCHO NWANFI

Wecyclers vehicles deliver their loads to one of the company's three collection and processing hubs in the city. Rafiat Ayoola is the operations lead at the largest hub. She interned at Wecyclers as a student and became a full-time employee in 2016. Today, Rafiat Ayoola is responsible for the supervision of around 50 on-site employees and is also involved in the training and onboarding of franchisees, helping them establish new collection hubs and ensuring they have the knowledge and equipment they need to run a successful business.



At the hub, materials are weighed, separated, and taken to sheds dedicated to the handling of various material categories. “The range of materials we handle has expanded,” says Rafiat Ayoola. “We now collect glass bottles, for example, and we are working with BASF on a project to recycle polystyrene packaging. It’s the first time that has been done in Nigeria.”



Staff at the hub begin processing materials as soon as they arrive at the shed. PET bottles are sorted by color, and caps and labels are removed to produce high-quality, consistent batches that are suitable for mechanical recycling.



PHOTOS: NYANGHO NWANFI

Sorted materials are compressed into 300-kilogram bales, so they are easier to handle and store on the site. “It makes a big difference, because one bale of PET bottles contains as much material as 14 bags,” says Rafiat Ayoola. Materials are taken from the site to local manufacturers, where they are transformed into a wide range of products, from tissue paper to furniture.



BASF is working with Wecyclers to develop innovative recycling routes for plastic materials. The Waste-2-Chemicals pilot project, which will go live during 2023, will chemically process polyethylene, polypropylene and polystyrene, transforming them into pyrolysis oil that can be used to manufacture new plastics.

Learn more at [basf.com/en/waste-2-chemicals](https://www.basf.com/en/waste-2-chemicals)

An extra layer for the climate

To limit the cost of heating and cooling, you need air – and that air needs to be enclosed. We demonstrate how insulating materials build on this.

What do feathers, fur, and woolen sweaters have in common? They all seal in a lot of air between their fibers or pores. This is how they retain warmth in winter, because stationary air is a poor conductor of heat – and therefore a good form of insulation.

This simple rule of physics is also used by insulating materials made from polystyrene in sustainable construction. The synthetic material exists in the form of expandable polystyrene granulate (EPS) and extruded polystyrene (XPS). EPS is familiar to most people – as white Styropor®. In expanded form, it consists of thousands of air-filled beads, for which the granules have been foamed up to 50 times. Today, this classic is used mainly for packaging.

In construction, it is mostly the enhanced, gray Neopor® that is used for facade insulation. Here, heat radiation is also blocked by graphite particles. In this way, insulation panels with up to 20 percent better thermal insulation can be produced. With XPS, such as the green Styrodur®, the synthetic material is expanded, pressed into a strand, and cut into boards. This means the insulation withstands greater pressure and is less sensitive to moisture.

Both are good for the climate, whether produced conventionally or based on renewable raw materials. This is because thermal insulation made from polystyrene saves heat energy and therefore reduces CO₂ emissions.

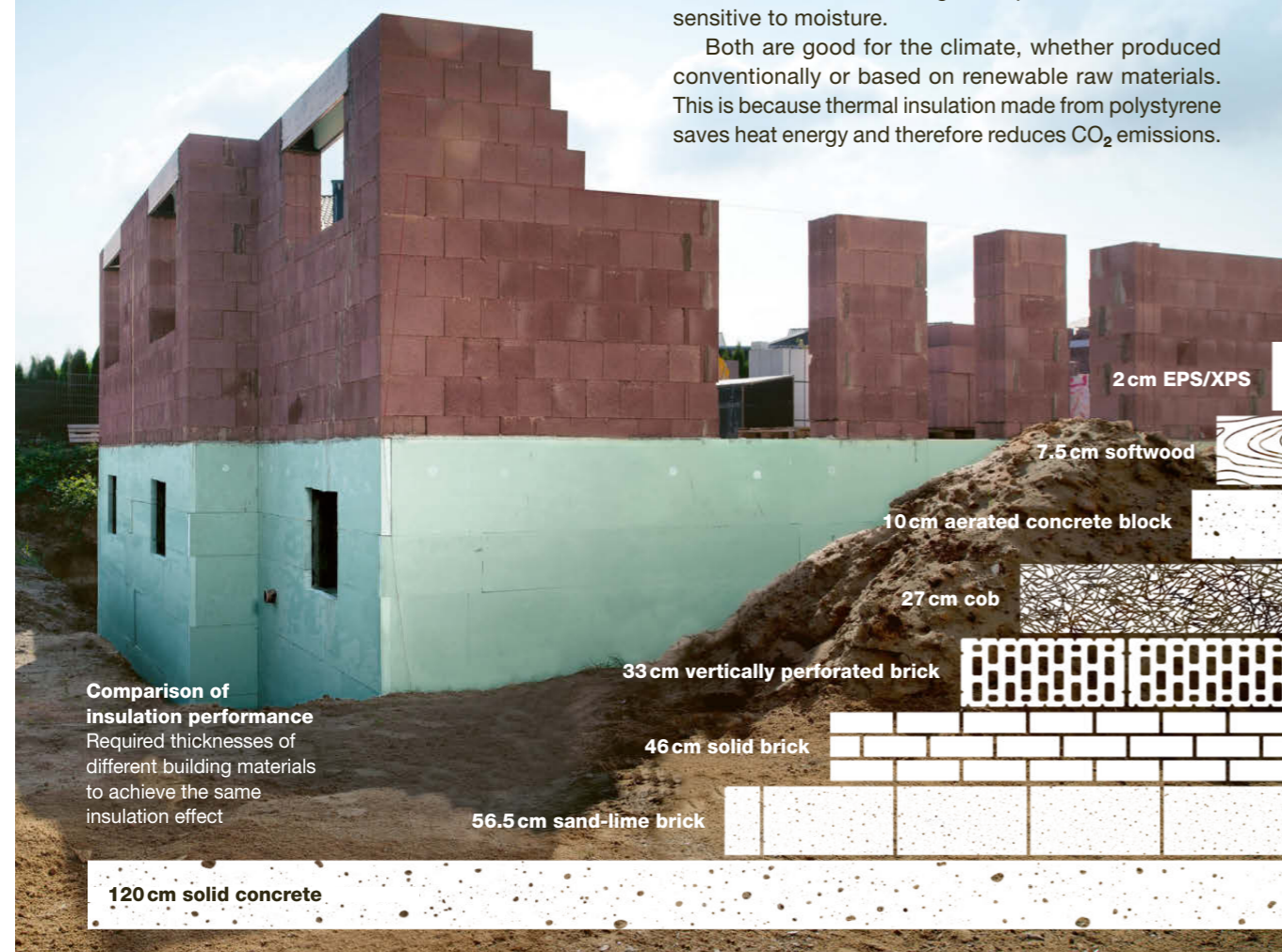


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At BASF, we create chemistry for a sustainable future. Our mission: Developing sustainable and innovative solutions through chemistry that benefit society and the environment, while also creating economic value.

Augmented Reality (AR)

Scan this page to find out more about the world of BASF.



PHOTOS: BASF SE; GRAPHICS: ASCS / JULIA ZIMMERMANN

How to use AR

Curious about what we at BASF are doing to protect the climate? Find out more in our video! Scan the QR code or download the free snoopstar app to your smartphone to discover more.



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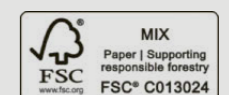
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Who's thinking inside the box to protect the climate?

To protect the climate, we're changing in all kinds of ways – like supplying the innovative insulating materials used in tiny houses made from upcycled shipping containers. Now heating and cooling these homes is much more efficient – reducing emissions and helping to protect the climate. This is all part of our commitment to protecting the climate.

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