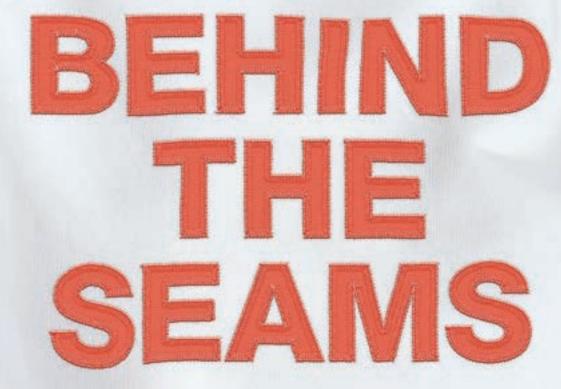
Creating Chemistry

Underground talents How the magic of mushrooms inspires scientists

Regenerative AI Machines are taking on the planet's toughest problems



How fashion can be kinder to the Earth



Fashion conscious

Clothing: We wear it on our skin, own too much of it and keep buying more. The label provides basic information about origin and production, but there is much more we should know about the impact of our choices on people and on the environment. It's time to take a closer, more critical look at our purchasing behavior – because responsibility is everyone's business.



WHAT DOES MY WARDROBE OFFER?

Look twice and get creative: Repairing, upcycling or second-hand fashion saves CO₂ and conserves resources.



HOW DO I KNOW WHAT'S GOOD?

Insight for a more sustainable choice: Certifications ensure transparency.



WHO PAYS THE PRICE FOR MY BARGAIN?

What happens if we don't curb our desire to buy? Squandered resources, mountains of waste and intolerable working conditions. Try clean only



Our comic strip on page 20/21 shows the impact of our consumption, and how we as consumers can make responsible purchasing decisions.

Dear readers,

We are all familiar with it – one click in an online store, and the parcel is already on its way. When it comes to clothes, we like to buy them frequently, even though we already have enough. We use fashion to express who we are – or maybe who we would like to be. But unfortunately, we ignore the downsides far too often – the frequently poor working conditions, mountains of old clothes, and the waste of resources. The fashion industry generates more greenhouse gas emissions than all international air and sea travel put together. How can we move toward fashion that is also kind to the planet?

Our cover story looks for answers to this question. It is not an easy undertaking, and we can't cover everything, but our aim is to inform and encourage. After all, there are promising approaches out there that could reduce the environmental harm caused by fashion consumption. One of these is our #Seed2Sew project in Greece, which is making cotton cultivation more sustainable and supply chains more transparent. Others are the use of alternative raw materials and new approaches for textile recycling. We also introduce you to three young designers who, in their own unique ways, are all standing up for greater sustainability in the industry.

Moreover, discover why fungi are inspiring scientists and what new materials can be made from them – such as living robot skin or low-carbon building materials. In addition, find out how artificial intelligence is giving sustainability a boost, and how innovative projects using minimal resources can improve the health of millions of people.



I hope you enjoy our latest issue of Creating Chemistry and feel inspired!

Mailin Rudenil

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



Your opinion is important to us

How do you like Creating Chemistry? 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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Focus: Fashion

Clothing collections with zero textile waste – this is the credo of designer Jessica Chang.

Algae is gaining attention as the textile industry looks for sustainable raw materials.

This catwalk in a Greek field showcases fashion made entirely from cotton produced as part of BASF's CSF program.

Wear it well

Forging a path to earth-friendly fashion

n all likelihood, while reading this article, you are wearing clothes – just as people have been doing for around 170,000 years. At first, they used leaves and fur to cover their bodies. Nowadays, clothing is like our second skin. It shows who we are, or want to be. In 2022 alone, the average U.S. citizen purchased around 68 pieces of clothing, according to the American Apparel and Footwear Association. And the numbers are similar in other industrialized nations. But why do we keep buying, even when we have enough?

"Shopping activates biochemical processes in our brain similar to those triggered by taking cocaine or falling in love," explains Carl Tillessen, chief analyst at the German Fashion Institute in Cologne and author of a bestselling book about consumerism. It is completely irrelevant whether we need the item or not; it's all about the feeling when we buy it. "Fashion in particular offers a quick and easy way to satisfy our ostensible needs, because it attracts us with constantly changing trends."

While a new outfit can brighten your mood, there is often a dark side to garment production. The fashion industry is responsible for about 10 percent of all CO_2 emissions – more than international aviation and maritime transport combined. Not to mention water pollution and mountains of discarded textiles, a consequence of cheaply produced "fast fashion" that constantly launches new collections. Tillessen urges us to become more aware of what we really need and the conditions under which our clothing is produced. For workers, these conditions are often catastrophic, as disasters like the collapse

of the Rana Plaza factory in Bangladesh in 2013 show. "That is just one of many dreadful examples of the poor working conditions in low-income countries, where child labor is common despite numerous national and international efforts."

Assessing the sustainability of fashion purchases is not easy. Sustainability is a multidimensional term encompassing environmental, social and economic components. This article cannot cover all aspects, but it aims to both inform and encourage - because there are promising solutions out there. Innovative technologies, alternative raw materials and new legislation are creating opportunities to reduce the environmental impact of fashion consumption. And we as consumers have influence, too. Let's start with fibers.

" We are unwilling victims of a global machinery based on manipulation and exploitation."



NOT AS GOOD **AS IT LOOKS**

Close your eyes and put your hand on your heart: What do you feel (besides your heartbeat)? Statistically, it's most likely to be polyester, since that is the most commonly used textile fiber. Let's take a closer look.

It is expected that nearly three-quarters of all textile fibers processed worldwide will be synthetic by 2030, and 85 percent of these will be polyester. It is lightweight, tear-resistant and dries quickly - a brilliant invention to be sure. But synthetic fibers, such as polyester, acrylic and nylon, are not biodegradable and release microplastics. When washed, synthetic garments release around half a million metric tons of microfibers each year that end up in the ocean, according to the Ellen MacArthur Foundation. Spanish fashion group Zara Home now offers a detergent that can reduce microfiber shedding by up to 80 percent during a wash cycle. The product, jointly developed by BASF and Zara's parent company Inditex, has already been launched in Mexico and Europe and is particularly suitable for washing at low temperatures.

benefit the environment. They produce a vegan from bulrus regenerativ ture. Read

Ponda makes materials that alternative to goose down grown by d agricul ge 15.

It protects the fibers, increases the useful life of textiles and lowers the environmental footprint of doing laundry.

Synthetic fibers are not your thing? Then your second skin is probably made of cotton, the second-most commonly used fiber. But, like synthetic fibers, cotton does not have an entirely impeccable record. There are many reports about human rights violations on cotton plantations, such as forced labor in Turkmenistan. In addition, cultivating cotton requires many resources, from huge fields to vast amounts of water. For example, it takes 7,500 liters of water to make one pair of jeans and a large part of this is for growing cotton, according to the United Nations. But there is a different way, with sustainably grown cotton. We will come back to this later.

Fibers made of other renewable raw materials can be more resource-efficient. Hemp, for instance, was already being used to produce textiles in China about 6,000 years ago. Compared to cotton, this undemanding plant needs only half as much water and produces 220 percent more fiber. Yet, hemp is still just a niche product in the garment industry. For one thing, it is much more difficult to process than cotton. And because of hemp's reputation as a "drug plant," its cultivation was banned in many places, so farmers are often unfamiliar with it. This is not the case in China, a pioneer when it comes to hemp textiles. The country currently produces more than 50 percent of the world's industrial hemp. Besides hemp, a number of alternative raw materials offer enticing potential. See page 18 for more. But whether polyester, cotton or hemp – all thread needs color.



It's hard to imagine blue jeans without their signature blue or a summer dress without a bold pattern. But colorful outfits have their price.

Our ancestors also liked brightly colored clothing and used substances found in nature to dye their textiles. For example, sea snails from the Muricidae family could be used to make the radiant Tyrian purple dye, which was so precious that it was only available to the elites. Or there was indigo dye - the "blue gold" derived from natural pigments that colored the linen strips used to wrap Egyptian mummies. These days, in the majority of cases, it is synthetic dyes that are used to make our outfits colorful. Dyeing processes not only require a lot of energy and chemicals, but also enormous quantities of water. According to the World Resources Institute, around 5 trillion liters of water are used to dye fabric each year - enough to fill 2 million Olympic-sized swimming pools. One of the consequences is that, according to the U.N., about 20 percent of industrial water pollution worldwide is due to dyeing and textile treatment. It is an open secret that untreated water from dyeing factories is being illegally discharged into rivers.

Dyeing doesn't just have a negative impact on the environment, it is also harmful to the health of people who work in the sector.

g

One example is tanning and coloring leather, which uses chromium salts, alkaline solutions and dyes. People who work in leather processing in low-income countries often have no or only rudimentary protective gear, so they come into direct contact with these substances – often with severe health consequences.

The search for sustainable alternatives means that natural dyes are making a comeback. The Swedish startup Mounid, for example, has developed an algaebased dye. When applied with spray technology, it consumes up to 90 percent less energy and water than conventional dyeing methods. Because of the fine atomization, it is usually more precise and requires less dye. In contrast to other natural raw materials, microalgae do not compete for arable land and can be produced quickly in large volumes. But for the time being, it is impossible to produce alternative dyes at the scale needed by the fashion industry.

One thing that is abundantly available is used clothing. Let's explore what happens – and could happen – with the clothes we no longer use.

We need more circular economy."

Professor Edwin Keh CEO Hong Kong Research Institute of Textiles and Appare





Significantly more than 80 percent of the materials used to make clothing worldwide end up in landfills or get incinerated. In the E.U. alone, around 5.2 million metric tons of used clothing and shoes are discarded each year, and only a tiny fraction of these get recycled. What's going wrong?

"What we need is more circular economy," insists Professor Edwin Keh, CEO of the Hong Kong Research Institute of Textiles and Apparel. "Our garments are often made of synthetic blended fibers that are difficult to recycle." Until now, sorting for fiber-to-fiber recycling has been complex and expensive.

Although the mechanical separation of fibers is a technically established process, knowing the fiber and mixture composition is important to ensure optimal recycling. However, this is difficult when garment labels are missing, faded or contain incorrect product information. This is where near-infrared (NIR) spectroscopy can help. The established method, which already supports material identification in plastics recycling, utilizes near-infrared light to make molecules vibrate. The vibrations, which vary from material to material, are detected by a sensor and compared with a database so that the result indicating the textile type is available in a matter of seconds. BASF's subsidiary trinamiX has developed a compact NIRbased solution for sorting textile waste by composition, which helps keep garments that can no longer be worn in the textile loop. The solution is applied, for example, by Germany-based Soex Group, a global leader in recycling used textiles.

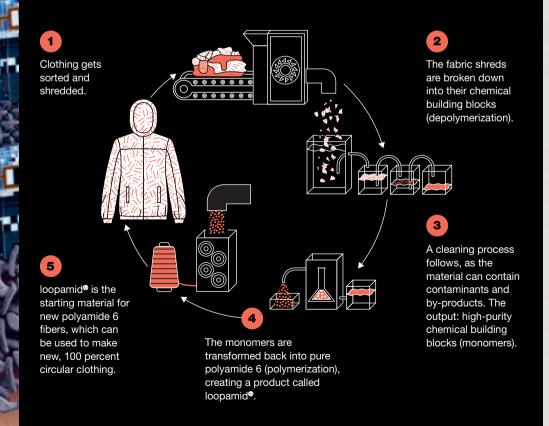
Imagine you could print your own clothes at home! Young designers such as Danit Peleg are leading fashion into this future with their 3D-printed collections. Read more on page 14.

Chemical recycling can bring us closer to a circular economy by turning used plastic into clothing. In chemical recycling, the long plastic polymer chains are broken down into their basic building blocks. "The benefits are less waste, less resource use and less pollution," says chemist Izzy Manuel. She is an influencer for ethical "dopamine dressing" – a colorful clothing style that aims to lift the spirits – and an influential voice advocating for sustainable fashion in the United Kingdom.

Sustainable fibers and dyes. This sounds good and feels good. But how can we tell how our new favorite T-shirt stacks up?

New threads from old

BASF has developed an innovative solution for textile-to-textile recycling. A chemical recycling process can transform old clothing into loopamid[®], a starting material for new polyamide fibers, which can be used to make new 100 percent circular clothing.



snoopcode



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Follow us on the trail of cotton to Greece. Scan the code to watch the video and discover much more.

TRACKED FROM FIELD TO FITTING ROOM

To purchase clothes consciously, we need transparency along the entire supply chain.

BASF's #Seed2Sew project in Greece shows how this can work in Europe's largest cotton-producing country. #Seed2Sew is part of BASF's Certified Sustainable FiberMax® (CSF) cotton program since 2022. CSF promotes the sustainable cultivation of cotton – lower COge* emissions, less water consumption, and the precise use of crop protection products and fertilizers. In addition, careful soil cultivation, crop rotation, regular soil analyses and drip irrigation protect soils and save water and energy. About 1,600 farmers, three cotton ginning plants and one spinning mill are participating in the program, annually producing about 50,000 to 55,000 bales of cotton.

#Seed2Sew now also addresses the transparency of the cotton supply chain from seed to retail. "We are using blockchain technology to make the cotton supply chain more transparent and traceable," explains BASF blockchain expert Abhijeet Sharma. A blockchain is a database that stores data in digital blocks chronologically as a data chain. The data chains are stored on different, networked computers that



In this field near Komotini, Greece, cotton takes center stage. It is sustainably produced as part of BASF's CSF program. Every step can be traced via blockchain – from the field to the shop. monitor each other. The system is considered particularly transparent and secure, as tampering is quickly spotted. Farmers record their sustainable cultivation activities via a blockchain-supported app. The data is linked to a scannable QR code on each cotton bale. "In the end, the finished garment can also be tagged with a QR code, so every step can be tracked from the field to the end consumer," says Sharma. Five farmers, a ginner and a spinner, as well as manufacturing partners, are involved in the blockchain project #Seed2Sew. This is approximately equal to 315 hectares of cotton-producing land that could generate 2,100 lint bales, with the potential to make more than 2.3 million T-shirts.

BASF has set up a similar project in the United States. The e3[®] Sustainable Cotton Program empowers cotton farmers to showcase their sustainability efforts, and offers brands in the fashion and textile industries access to transparently sourced, sustainably produced cotton.

QR codes are not the only way to get information about our clothes. Textile standards also offer us clues. If you look at the tag inside your clothes, do you see a label with a seal? You have made a sustainable purchase if you find one showing a white shirt on a green background. The GOTS (Global Organic Textile Standard) seal is one of the strictest textile standards worldwide. It considers environmental and social criteria throughout the entire supply chain. Another very strict environmental standard is the IVN Best certification from the International Association of Natural Textiles (IVN e.V.).

IVN covers the supply chain for natural fibers, from organic farming to the final product. But not all certifications are this comprehensive. The Oeko-Tex® Standard 100, for example, is one of the world's best-known labels, but it only tests for harmful substances in the final product. It does not provide any information about the production or environmental impact of a garment. So it's definitely worth checking closely which certification labels are on your clothes. But these standards alone are not enough.

Continued on page 16

Virtual is en vogue

Isn't it annoying when jeans look great in the online shop but turn out to be too small, too big or just not right? Returning unwanted purchases is a hassle, and it causes packaging waste and transport-related CO₂ emissions. A virtual changing room, such as the one offered by German online retailer Zalando, might help. A customer enters a few parameters into the app, such as their height and weight, to create a personal avatar that can enter the virtual fitting room. Even fashion shows are moving into the digital realm. Labels such as Dolce & Gabbana, Tommy Hilfiger and DKNY sent avatars onto the digital catwalk during Metaverse Fashion Week 2023. This saves fabric because the collections do not have to be physically produced for the show, and avoids CO₂ emissions associated with transport and travel. Virtual fashion is nothing new in the gaming sector. Fortnite players, for instance, have long been able to purchase "skins" to deck out their avatars.

Here's how it works: pixels replace cloth

Technologies such as augmented reality or 3D software can replace sewing machines and the like

Advantage:

saves resources No material consumption, waste or travel

Disadvantage: raises (new) legal questions

Especially regarding transfer of rights and copyright

With 3D printers, bulrushes and upcycling: Young designers are creating fashion that suits our planet better

Danit Peleg

PRINTING FOR CHANGE

"Imagine a world where we buy digital files of clothes, download them and print them at home."

"Imagine" is written in bright red letters on Danit Peleg's 3D-printed jacket. Its creator herself sparkles with imagination. In thousands of hours of tinkering in her Tel Aviv studio, the Israeli has inspired the fashion industry. A graduate of Shenkar College of Engineering and Design, Peleg was the first in the world to create her graduation collection at home using standard 3D printers - and she was the first to offer such clothes in her own online shop. "I enjoy experimenting with new materials, and I am interested in pushing the boundaries of printing techniques and software developments to make fashion fit for the future," she says. The 35-year-old's vision: In the future, consumers will buy digital files to print and personalize their clothes themselves using affordable 3D printers. "That way, there will be nearly no waste, and the supply chain will be circular and hopefully radically cleaner," she says. The BBC chose Peleg as one of its 100 Women for 2019. See Danit Peleg's fashion on page 10f.





Julian Ellis-Brown

COZY BULRUSHES

"We were looking for a material that warms without harming the environment or animals."

When Julian Ellis-Brown speaks, even King Charles III listens. The young CEO and co-founder of the startup Ponda presented the British monarch with a tailor-made stepped vest in summer 2023, explaining the benefits of its sustainable filling, and the "green king" was all ears. The idea for the fluffy filling material called BioPuff® - an alternative to down - came to Ellis-Brown and three of his fellow students during their master's program in innovation and design technology. They found bulrushes plants capable of sequestering carbon and recultivating soil. "What drove us was the idea of a design that would actively help saving the planet," he says. In the lab, the four students developed a method for extracting a soft filler material from the plants' rough bulbs. For its innovative idea, Ponda has received the Global Change Award, among other honors. Not yet 30 years old, the tireless conservationist is already working on the next new bio-materials together with various research institutes. See Julian Ellis-Brown's fashion on page 8f.

Jessica Chang

<u>SECOND CHANCE,</u> <u>FIRST PRIZE</u>

"Upcycling means to reuse materials that previously ended up as waste and give it a new life."

Whether it's unsold textiles or secondhand clothing, Jessica Chang gives it all a second chance. "Just as fashion trends are recycled, worn clothing can be too, so it doesn't end up in the trash," she says. The young designer grew up in Hong Kong and studied fashion design in New York. With her upcycling approach and reuse of textile waste, she is impressing the fashion world. Her collection "The Wall" won the Redress Design Award 2021, one of the world's biggest competitions for sustainable design. The presented pieces are extra durable thanks to breathable openings, which ensure less sweating and less need to wash the clothes. Although Jessica has demonstrated the potential of discarded textiles, she herself avoids rejecting items wherever possible. "I am currently working on my fashion label PCES, which focuses on zero-waste patterns and recycled textiles to avoid any textile waste." she says. See Jessica Chang's fashion on page 16f.

Focus: Fashion



"We need government leadership to make the industry fairer by law," says British social entrepreneur Safia Minney. What are governments around the world doing to make tailor-made fashion laws?

Many fashion companies have already recognized the need to act. One pioneer when it comes to sustainability is U.S. sportswear manufacturer Patagonia, which received the U.N.'s Champion of the Earth Award for its commitment. The company has been using recycled plastics since the 1990s, and launched a recycling program for its own clothing in 2005. In addition, it has established a social responsibility program for its supply chains. Many other producers have now done the same.

Advertising sustainable collections is now basically part of the standard repertoire of fashion labels. About 100 of these companies have signed the United Nations' Fashion Industry Charter for Climate Action. As signatories, they commit to reducing their greenhouse gas emissions by 50 percent by 2030, as compared to 2019 levels. However, the environmental organization Stand. earth studied 10 of these companies and found that Levi Strauss & Co. was the only one likely to reach this target. "We need to bring about a cultural change among fashion companies and redesign the industry that it fits our planet and becomes fairer," says Safia Minney. She is the founder of the ecological fashion label People Tree. It is considered the first label in the clothing industry with a completely sustainable supply chain, including strict certification - such as the GOTS seal.

The European Union wants to introduce a directive on corporate sustainability due diligence, which will apply to companies in all sectors, including the apparel industry. This law would oblige larger E.U.-based companies and foreign

companies with a certain level of sales in the E.U. to protect human rights and the environment throughout their global supply chains. Moreover, the E.U. also wants to promote the circular economy. As a key component of its Green Deal, Brussels is about to adopt an Ecodesign regulation. The final discussions between the European Commission, Parliament and Council are under way. Among other things, this legislation would introduce an E.U.-wide ban on the destruction of brandnew textiles and shoes that are unsold or returned to the store. In general, its aim is to ensure clothing becomes more durable, easily recyclable and environmentally friendly by 2030.

Policymakers in other parts of the world are also taking action. In the United States, a new legislative proposal called the Fashion Act has been introduced in the state of New York. One goal of the law is to improve working conditions. At the same time, companies that want to sell their goods in New York state will be obligated to reduce their emissions in line with the Paris Agreement.

"It's the lifestyles of people in the North that are responsible for global warming, yet people in the Global South are bearing the brunt of climate and ecological collapse, and simultaneously fashion's buying practices and trade terms are getting worse. We need to face into the responsibility that is calling all business leaders," says Minney, who is also a founding member of the global network Fashion Declares. This is primarily concerned with "accelerating change in one of the most environmentally damaging and unfair sectors in the world," says Minney. As well as publishing informational materials, the initiative offers regular webinars and launched the Regenerative Fashion Conference. "We need more

Designer Jessica Chang's collections feature recycled textiles and zero-waste patterns. More about her work on page 15.



We need to bring about a cultural change among fashion companies."

Safia Minney Founder of People Tree

transparency and collaboration among ourselves, we should share best practices and spark industry-wide debates," the entrepreneur adds. Industry alliances face enormous challenges, as the example of the Partnership for Sustainable Textiles makes clear. It was initiated by the German government in 2014 in response to the Rana Plaza disaster. The Partnership advocates for a socially and environmentally responsible, corruption-free textile and garment industry. In the meantime, some members, such as the Clean Clothes Campaign, have left the initiative, saying the alliance has not improved working conditions in the global fashion supply chain.

Worldwide, policymakers and apparel brands have put sustainable fashion on their agenda. And many young designers have sustainability in their DNA (see page 14 f.). But to achieve sweeping changes in the industry, consumers will also have to do their part. "People buy more clothes and throw them away faster," points out Professor Keh. Let's look at how consumers can contribute.

Alternative chic

Innovative raw materials such as algae, grapes and fungi are taking the fashion world by storm.

From fungi to leather

Scratches on your leather bag can be unsightly, or even ruin its look. Researchers from the U.K. have developed a leather alternative that can repair itself This wonder material is made of mushrooms, specifically mycelium, the mushroom's dense, root-like filament structure. When placed in a special fluid, renewable structures grow to fill in any scratches on the surface. MycoWorks, a U.S. biotech company, is already supplying mycelium-based imitation leather that can be manufactured into accessories such as hats. For more on fungi's fabulous potential, see page 26.

🔗 mycoworks.com

Carbon cool

What do marine organisms have to do with sunglasses? Quite a lot, according to the U.S. company Newlight. It uses these microorganisms to transform methane and carbon dioxide into a biodegradable plastic alternative called AirCarbon. This can be used to make products ranging from sunglasses to cell phone cases. Read about other ways to use CO₂ as a raw material on page 38.

🔗 newlight.com

A grape idea for accessories

Every year, around 26 billion liters of wine are produced worldwide – leaving behind millions of tons of grape skins. These are too valuable to go to waste, believes French startup Planet of the Grapes. From grape marc (the grape waste produced by vineyards), it has developed a leather alternative which can be used to make handbags or wallets, for example.

planetofthegrapes.fr

Nautical yarn

From the sea to the catwalk: As a sustainable raw material for thread, kelp offers many advantages. It grows quickly and does not require synthetic fertilizer. U.S. company Keel Labs produces a biopolymer from kelp. In a test phase, it is transforming this into an elastic fiber which can be used to make washable T-shirts and other garments. What's remarkable: This material is fully biodegradable. So an old seaweed shirt can be discarded in the garden compost.

keellabs.com/kelsun

Sustainably stretchy

Elastane fibers can stretch by as much as 70 percent, and are what make our clothes elastic and flexible. They are produced from the intermediate product PolyTHF, which is usually made from butanediol derived from natural gas. Starting in 2024, BASF plans to offer a bio-based alternative with the same quality. It will be made without fossil raw materials and therefore will release less CO2. The new feedstock for PolyTHF is butanediol derived from cornstarch, which BASF sources from the U.S. firm Qore.

bit.ly/bdoqira





We buy more than we can wear and our closets are stuffed to the brim. If something's damaged, we toss it in the trash. But there is another way!

Quality over quantity: You can be welldressed with just a small wardrobe of high-quality basics (ideally with a textile certification). A "capsule wardrobe" contains pieces that can be combined with each other to make various outfits for every occasion. One of the first capsule wardrobe collections was released in 1985: US designer Donna Karan's Seven Easy Pieces – seven items that could be mixed and matched. There are now many such collections on the market.

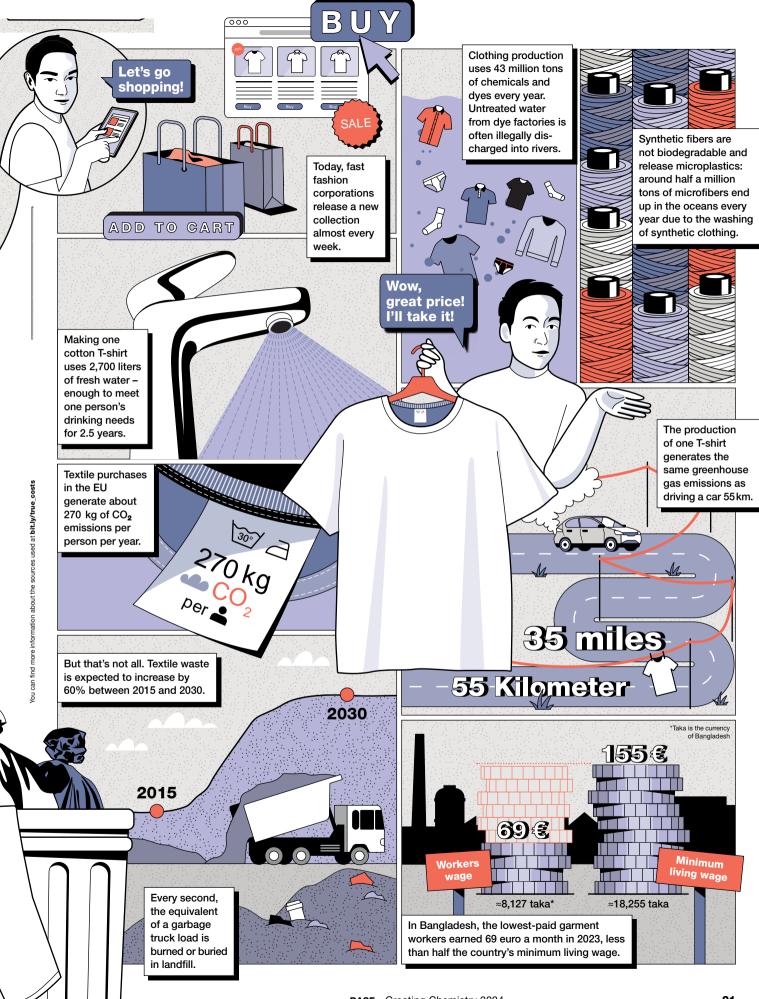
Getting a hole in one of your capsule basics does not have to mean it's time to toss the item. Some clothing, such as pieces from U.K. firm WoolOvers, come with matching yarn and buttons to repair the garment. If you don't have the skills or desire to fix it yourself, repair services are available. Online retailer Zalando, for example, started a pilot project called Care & Repair in 2021 and is now evaluating the program and its next steps. With this online service, customers were able to have their damaged clothing or shoes picked up at home and repaired by local businesses. By the way, in France, clothing repairs are now even subsidized by the government. Starting last October, anyone who takes their damaged apparel to a tailor or shoemaker is eligible to receive a repair bonus.

Or should your old coat be revived like the phoenix from the ashes? With its Renew program, U.S. fashion label Eileen Fisher offers a take-back service for items from its own collection. The clothing gets cleaned and partly upcycled. The company says that since 2009 it has taken back 1.9 million garments, which have been resold or transformed into new designs. This service does not only offer environmental benefits: Customers receive 5 U.S. dollars for each returned item of clothing – no matter what condition it is in. A similar approach is being followed by Swedish fashion label Asket. The company has opened a store in Stockholm, where it offers used and repaired Asket garments and is planning to host upcycling workshops for customers.

"The circular economy is beginning to shape clothing production, and on the consumption side, buying secondhand, rental and repair offer a way to reduce the ecological impact of fashion," says Safia Minney, who has been buying secondhand fashion and trading clothes since she was 17. Meanwhile, her nieces benefit from the clothes she no longer wears. For those who don't have an aunt who is a fashion designer: Online platforms such as Rent the Runway offer designer clothing and accessories for rent. More than 140,000 people currently use the U.S. firm's clothing subscription service.

"In our society, we are used to buying lots of clothes on a monthly, weekly or even daily basis. It can be hard to break that habit. To do so, before I make a purchase, I ask myself: Will I really wear this? Am I buying it just because it's a bargain or because I'm in a buying mood right now?" The maxim when it comes to your own wardrobe should be: Slow down! Be intentional and inform yourself before buying something new. Buy fewer items but carefully chosen ones of good (recycled) quality. And, wherever possible, trade or upcycle. Our clothing choices determine how much responsibility we take on for people and our planet.





In 2007, while working as a journalist, Christina Dean saw the environmental impact of the garment manufacturing sector at first hand. The experience prompted her to campaign for a more sustainable approach to fashion.

"We need a revolution"

Hong Kong-based environmental charity Redress is on a mission to reduce the environmental impact of the fashion industry. It works to inspire and educate consumers and designers, encouraging them to embrace the circular economy. Founder and Board Chair Dr. Christina Dean tells us there is still much work to be done.



Dr. Christina Dean

Dean is a sustainable fashion advocate who has championed better practices in fashion for more than 15 years - for example, via the renowned Redress Design Award honoring young talents. Dean was listed as one of British Vogue's Top 30 Inspirational Women.

B orn and brought up in the U.K., Christina Dean didn't expect to become a sustainable fashion activist. She first worked as a dentist, then retrained as a journalist. After moving to Hong Kong in 2007, she took on assignments covering the impact of industrial pollution. That opened her eyes to the environmental costs of the fashion industry. Within months, Dean had switched careers again, founding Redress, which claims to be Asia's first nongovernmental organization focused on the fashion industry.

Can fashion ever be truly sustainable?

I think the answer is no, but a lot depends upon your definition of sustainability. Far too often, people think about sustainability in the fashion industry only in terms of environmental considerations. I did that too, for a long time. But it is more complicated than that.

If you take a broad view, as the U.N. does with its sustainable development goals, then sustainability is about the economy, the environment and the social side of things. So let's transfer this onto fashion. In an ideal world, the fashion industry would create truly closed-loop systems, with renewable fibers, recycled materials and a work situation that was fair and empowering for everyone involved. We have a long way to go, but we should aspire to get closer to that ideal.

What are the most critical issues facing fashion in terms of sustainability right now?

The most critical issue facing fashion today is the lack of circularity. We also have overconsumption, we have cheap fashion, and we have a lack of recycling. That means we are putting pressure on the environmental and social dimensions of sustainability. We are screwing up the environment and we are driving down wages to make cheap clothes.

You might argue that fashion is succeeding economically, because the industry is making big bucks, but it is doing that in a hugely inefficient way. We are incurring vast costs to mitigate the environmental impact of the sector. And we are not capitalizing on what the Ellen MacArthur Foundation estimates is an economic opportunity of 500 billion U.S. dollars to transform the way clothes are designed, sold and used: switching to renewable inputs, ramping up recycling and increasing the utilization of the clothes we own.

Without any hesitation, the industry has had a wake-up call."

Is the fashion industry aware that it needs to do better? And is the industry trying to do better?

Without any hesitation, the industry has had a wake-up call. If you look at the biggest fashion groups – the top 20 or so companies that account for most of the industry's revenue – then I think we have seen significant progress in recent years. They've focused on efficiency improvements, carbon savings, waste reduction and on the working conditions in their supply chains.

But this is not enough. We urgently need actions outside the direct control of the big fashion players. That will involve supply chain partnerships and collaboration with other industries, from the fiber manufacturers and recycling companies to energy players and chemical companies. We are already seeing fashion companies making direct investments in renewable power projects, for example.

How could change be accelerated?

The fashion industry needs to make a lot of changes in a very short period. That's actually the definition of a revolution, and we need a revolution. You can point at countless new developments in R&D labs around the world over the past 10 or 15 years: in new materials, new fabrics and new processes that could achieve true circularity in the sector. Now we face the challenge to scale up all those great ideas. But scaling up costs money. Boston Consulting Group and Fashion for Good produced a great report a couple of years ago looking at the technology requirements for a circular fashion supply chain. It estimated that the fashion industry needs 20 to 30 billion U.S. dollars in financing every year until 2030 to develop and commercialize sustainable solutions and business models. Closing that gap will require the combined efforts of philanthropic organizations, venture capitalists, private investors, financial institutions - and the fashion industry itself.

But sustainability is not just a cost factor, it can also drive commercial returns: There's now so much evidence that sustainable business plans and thoughtful environmental, social and governance (ESG) strategies lead to greater longterm profitability. One study of large firms found that companies with high ESG standards have seen their incomes and profits grow more than twice as fast as those that haven't yet made it a priority. I think that people in the C-suites have a carrot right in front of them, which is seizing the market opportunities offered by sustainability.

Can we leave it to the industry to achieve that revolution, or do governments and regulators also need to act?

I'm optimistic about the drive that many leaders – not all, but most – in the industry have to improve the sustainability of their businesses. Nevertheless, you need regulation to achieve a fair playing field. But effective regulation is difficult to do. It takes a long time for governments to set up new rules. And they need to work with the industry to create regulations that can be implemented without destroying the sectors they are trying to reform. If governments get that wrong, the proposed regulations end up being abandoned, and you face another 20 years without a referee on the pitch. That said, regulations can be a catalyst for change in the sector. A good example of that is France, which has introduced rules to stop large fashion businesses from incinerating unsold products that could be reused or recycled. That has sent these companies into a state of action: forcing them to rethink the way they handle their inventories.

How does your organization Redress help companies and consumers to improve the sustainability of fashion?

At Redress, we focus on both ends of the fashion life cycle. We work to educate consumers about the impact of their fashion choices. We want to empower them to buy less, buy better and take better care. We run a take-back program for clothing in Hong Kong, and a charity shop. We do pop-ups, talks, exhibitions, digital publications and work with secondary schools.

And we work with fashion designers. As with most products, about 80 percent of the environmental impact of a garment is determined at the design stage. That's the point where you can build circularity in. The centerpiece of our engagement with designers is the Redress Design Award, which is the world's largest sustainable fashion design competition. In 2023, its 13th cycle, the award had 150 university partners across the world. Participants learn about sustainability through lectures and online courses, and the winner gets to work for a leading global fashion brand.

What about the role of the consumer in driving change?

The voice of the consumer is hugely influential on the decisions the big brands make, for example. What we buy really matters. And how we treat our clothing throughout its life cycle, too. Washing better, caring better, wearing longer, sharing – all this has a huge effect on our overall impact.

Our clothes are a wonderful way to express ourselves, but they also mean a great responsibility: Our choices say something about the sort of world we would like to live in. Our choices say something about the sort of world we would like to live in." Redress operates a network of clothing collection points across Hong Kong.

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Pre-loved clothes are sold at the Get Redressed Secondhand Pop-Up Shop, upcycled or used by local charities.

12-1



Christina Dean discusses sustainability in fashion at industry events, conferences and via an online documentary series.

Science & environment

Deconica

Mood booster

Many species in the Deconica genus are known as "magic mushrooms." The often cone-shaped fruit body of these fungi is rich in psilocybin, a hallucinogenic substance that recent findings show may help treat psychiatric diseases such as depression.

Talent from the underground

Fungi – they can be extremely small or impressively large. They can live deep in the ocean or way up in the stratosphere. They can be delicious or deadly. And thanks to their sheer diversity, new uses for fungi are popping up everywhere – from sustainable construction to climate-neutral chemistry. It is time to shine a spotlight on these versatile and multitalented organisms.

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he area surrounding the Chernobyl reactor in northern Ukraine was assumed to be completely contaminated. But in 1991,

five years after the devastating nuclear accident, researchers discovered something astonishing: A black fungus had spread over the walls of the reactor's interior. It was not just surviving there, it was absolutely thriving. The fungus – Cryptococcus neoformans – seemed to really love radioactivity. Scientists soon discovered why: The fungus contains high levels of the pigment melanin, which enables it to absorb radiation and transform it into chemical energy. Researchers are now investigating whether fungi with these properties can also protect astronauts from hazardous radiation in space.

Surprisingly diverse

According to biotechnology professor Vera Meyer, fungi "have incredibly diverse metabolic capabilities." Meyer is head of the Applied and Molecular Microbiology department at Technische Universität Berlin, Germany, and has been researching the world of fungi for more than 20 years. "It is their ability to adapt and change that I find so fascinating, including how they can switch between friend and foe." There would be no life as we know it without mycelium, fungi's root-like underground network of filaments, which delivers nutrients to trees and plants. Yet fungi can also damage organisms - by causing infections, for example. They come in many forms: from delicious, edible wild mushrooms on the forest floor to mold growing on an old piece of bread. And while a fungal spore may be as small as 2 to 10-thousandths

Mycelium

NUMPER N

Innovation driver

Mycelium, fungi's root-like web of filaments, not only provides nutrients for trees and plants, but can also serve as an innovative raw material. Researchers from ETH Zürich, for example, were able to produce a living robot skin from 3D-printed mycelium, which can regrow after being cut.



of a millimeter, the Earth's largest living organism is also a fungus: a specimen of Armillaria ostoyae in a U.S. national park whose mycelium stretches over an area of 9 square kilometers.

Smart networkers

"Fungi are everywhere, and they are all-rounders," Verena Meyer explains. "They are masters of both decomposition and synthesis." Using enzymes - in other words, biocatalysts - they can break down biogenic raw materials, such as wood or straw, into their components and then recombine and assemble these for a wide variety of products. Meyer and her team are bursting with ideas of how humans can take advantage of this. They are researching everything from fungi-based, sustainable bike helmets to clothing and packaging material. At the same time, she says, the many talents of fungi are also leading to a new wave of connection in the academic world. "The various scientific communities are now starting to communicate more intensively with each other," says Meyer. Researchers who previously studied only fungal proteins or enzymes now understand that "fungi could also be used to produce sustainable construction materials."

The possibilities in construction have also piqued Meyer's interest. With her interdisciplinary collective MY-CO-X, which brings together artists, architects and biotechnologists, she created an inhabitable sculpture made of fungi and wood. The 20 square meter wooden structure called MY-CO SPACE is inspired by The jelly-like yellow brain fungus produces carbohydrates with anti-inflammatory effects, which medical researchers are keen to study. These might help to treat diabetes and allergies, stimulate the immune system and protect against radiation.

Yellow brain fungus

Inflammation stopper

the design of a space capsule and is completely biodegradable. "The load-bearing components show the challenges facing fungal biotechnology: making materials durable and stable enough to compete with concrete," Meyer says. To achieve this, the researcher relies on composite materials. The fungal mycelium is grown in agricultural and forestry residues, such as straw, bark or sawdust, or in concrete recycled from demolition waste. As it grows, it compresses the particles into a hard composite material. The network of fungal filaments grows increasingly dense, acting like mortar that binds the concrete pieces together. The new materials are to be produced with low CO₂ emissions and be repeatedly recyclable.

Spotlight on the hidden champions

In her own artistic works, Meyer shows how mycelium material organically combines with other raw materials. Her fungi sculptures reflect the zeitgeist:

Gliocladium **Biofuel builder** "Mycodiesel" is what U.S. researcher Dr. Gary Strobel calls his concoction produced by a South American fungus when it is fed with cellulose. In the lab. the mushroom spec Gliocladium roseur produced small vol of non-fossil biofue



To transition away from fossil raw materials, we need to tap the potential of fungi."

Professor Vera Meyer Head of the Applied and Molecular Microbiology department at Technische Universität Berlin, Germany

In many areas - including the arts, pop culture, business and academia - there is growing excitement about the special characteristics and abilities of fungi. We are experiencing a real "mushroom boom." Fungi expert Gordon Walker, a Californiabased PhD biochemist, takes his more than one million social media followers on virtual strolls through the undergrowth. Mushrooms served as a muse for Icelandic artist Björk's 2022 album, Fossora, while photographers are capturing the aesthetic beauty of fungi. And industry and academia are looking to harness fungal metabolism to help the climate - by using the organisms to produce substitute meat products or resource-saving materials, for example.

The talents of fungi also offer many opportunities for industry. "If we want to transition away from fossil raw materials to renewables, we need to tap the potential of fungi," says Meyer. BASF is doing exactly that, putting the tiny organisms to work on a large scale. They feed on organic raw materials, such as sugar, and metabolize them into sustainable products. "This means they can replace chemical processes based on crude oil. Fungal biotechnology, along with bacterial and other processes, is therefore a key technology for us on the path towards climate-neutral chemistry," says Dr. Doreen Schachtschabel, Vice President White Biotechnology Research at BASF. Industrial biotechnology – also called white biotechnology – is poised to grow faster than the conventional chemicals business in the coming years. BASF's portfolio already contains about 3,000 biotechnology-based or biodegradable products. These range from flavors and fragrances to crop protection products.

Endlessly adaptable

"Fungi are particularly interesting for BASF, as the desired traits can basically be genetically inscribed – making them into efficient cell factories for industrial applications," says Dr. Stefan Haefner, industrial biotechnology expert at BASF. One promising microorganism is called Ashbya gossypii. In its conventional form, this fungus attacks tomatoes, hazelnuts and lemons. But in a genetically modified form, Ashbya gossypii becomes a smart cell factory. BASF researchers have been able to modify this fungus in such a way that it can produce large volumes of vitamin B2 in a bioreactor, also known as a fermenter.

Vitamin B2, which is essential for human and animal nutrition, used to be chemically synthesized. This was a complex, seven-stage process that required various chemicals and ultimately produced a small yield. "We have replaced this with a simple one-step process," says Dr. Birgit Hoff, project leader for industrial biotechnology at BASF. "We feed the fungus with plant-based oil, which it then converts into vitamin B2." Compared to the chemical process, the biotechnology process requires one-quarter less energy, produces one-third less greenhouse gas, and is resource-efficient thanks to the renewable feedstock. "But fungi are complex systems," stresses fungus expert Haefner. "Each one functions differently. Just because you are familiar with one and its metabolic pathways, you do not necessarily know the others." And this is exactly what makes fungi so useful.



Fungi are very talented and can help us to preserve an Earth worth living on."

Gordon Walker, PhD Biochemist



Water purifier

Melanin is in high demand in industry – and it costs more than gold! Researchers in Switzerland were able to obtain this pigment from the mullet honey fungus. Because melanin can bind heavy metals, it can be used to develop innovative water filters. "Thanks to their almost inexhaustible possibilities, they can be used to create an incredible variety of products."

However, much of this potential is still undiscovered: A research team from Berlin and London estimates there are somewhere between 2.2 and 3.8 million species of fungi, of which only 120,000 have been scientifically described so far. About 1,500 more are discovered every year. "At the same time, fungi – depending on their stage of development – display an amazing ability to change their appearance," says biochemist Walker, citing the example of the yellow brain fungus: On dead wood, it forms glowing fruit bodies when it creates gametes. However, the same species can also reproduce asexually, through spores, and it then appears as yeast fungus.

Ravenous for rubbish

Another fungus that reproduces in yeast form is the one that grows by transforming Chernobyl's radioactivity into chemical energy. "This is just one example of how fungi can be beneficial destroyers," says Walker. Others can also break down plastics. Farmers use this to their advantage with mulch films made from BASF's certified biodegradable polymer ecovio[®]. After the harvest, they simply plow the film under the soil, where microorganisms such as bacteria and fungi recognize the structure of the film and transform it into CO_2 , water and biomass – thereby returning the material into the natural cycle.

Walker is also fascinated by this cycle. If you observe fungal organisms, he points out, you recognize that there is no waste in nature – everything decomposes and is renewed in a veritable cycle. "Fungi are very talented and can help us to preserve an Earth worth living on," Walker says.

Oyster mushroom

Music maker

Artist MycoLyco uses mushrooms to create music. He connects pink oyster mushrooms or cordyceps to his synthesizer, making audible small electronic signals from inside the fungus. In low and middle-income countries ...

> ... many basic medicines are inaccessible:

70%

of people in low-income countries have not received a COVID vaccination

Bridging the health gaps

For billions of people around the world, the basic building blocks of good health are still out of reach. From nutritious foods to common medications, better access to the little things could make a big difference. 80%

Fraction of the world's population with zero or very little access to strong pain medications

... or unaffordable:

60%

Share of health spending used to buy medicines in some low-income countries

n Sierra Leone, Chad and South Sudan, around one in 90 pregnancies leads to the death of the mother. The maternal mortality risk

for a woman in the E.U., by comparison, is 0.006 percent – 190 times lower. What's behind this huge difference? In Europe, women are likely to be healthier and better nourished during their pregnancies and have access to superior healthcare – 98 percent of births are attended by skilled healthcare staff, and antibiotics and blood-clotting drugs are available to treat complications quickly and safely.

"It seems that poverty is the mother of inequality in health," says Mohsen Naghavi, Professor of Health Metric Science at the Institute for Health Metrics and Evaluation (IHME) at the University of Washington, United States. "Low and middle-income countries experience worse health outcomes than highincome countries: the life expectancy is 34 years lower, the under-5 mortality around 100 times higher, and deaths

90%

Share of the population in low and middle-income countries that purchases medicines through out-of-pocket payments

Care on the lin<mark>e</mark>

Access to medical facilities is an acute problem in many poorer rural communities. Mobile hospitals are one solution. The Lifeline Express is the world's longest-established hospital train. It has traveled through India for more than 30 years, bringing specialist care to millions of people.



attributable to antimicrobial resistance (AMR) are 12 times higher."

"An estimated 2 billion people do not have access to essential medicines and vaccines," says Marijn Verhoef, Director of Operations and Research at the Access to Medicine Foundation. "Research from five or six years ago suggested that around 6 million people die every year from treatable infections, because they don't have access to antibiotics. More recent research has shown that sub-Saharan Africa is the region that has been hardest hit by the rising incidence of drug-resistant infections."

Access denied

The true impact of limited access to medicines and health services may be even more severe, adds Verhoef, since much of the data used to create today's estimates was collected before the COVID-19 crisis. "We know that the pandemic had a negative impact on health systems almost everywhere in the world," he says.

Like any big global challenge, the underlying causes of unequal access to medicines are complex. Affordability is a major issue, says Verhoef, especially in countries where many patients must pay for healthcare from their own pockets. "Sixty percent of households in lowincome countries, 33 percent of households in lower middle-income countries and even 25 percent in upper middle-income countries cannot afford four commonly used cardiovascular medicines sold in private pharmacies," he says. "And 100 million people are pushed into extreme poverty every year by the cost of essential healthcare."

Then there's the supply chain. For a drug to be available to end users, its producer must obtain approval from local regulatory authorities, must decide on a pricing strategy, and must establish a supply chain to manufacture and distribute the product in the region.

Each of those steps is a potential weak point, says Verhoef. Medicine distribution networks might fail to reach local populations, especially those in remote and rural areas, or might be vulnerable to theft and corruption. Supply chains can also be affected by manufacturing shortages or policy changes. "In sub-Saharan Africa, 99 percent of the medicines used are produced overseas," he says. "During the pandemic, some of the producing countries that supply those markets took action to restrict exports, in order to ensure supply for their own citizens."

There's also the risk that pharmaceutical companies see supplying low and middle-income countries as too much work for too little gain. Ensuring that they don't ignore those millions of poorer patients is the mission of the Access to Medicine Foundation. Since 2008, the Netherlandsbased organization has evaluated 20 of the world's largest pharma players on their efforts to address current and emerging medical needs in these regions. It publishes its findings in a biennial Access to Medicine Index.

An estimated 2 billion people do not have access to essential medicines."

Marijn Verhoef Access to Medicine Foundation





Science & environment

The index rates pharma players on several dimensions, including whether they are developing products that address the key unmet medical needs of low and middle-income countries, whether launch plans for new medicines include these regions, and how companies support product delivery within them.

That scrutiny seems to be having an effect. For example, the latest Index, published in 2022, shows that all 20 companies analyzed now have an access-to-medicine strategy, compared to just eight in 2010. And 77 percent of latestage R&D projects have an associated access plan. There's still much work to do, however. Access plans for new medicines tend to focus on a relatively

We wanted to improve access to medicines, but we couldn't do it alone."

Fernanda Furlan BASF small number of regions, with companies favoring middle-income regions over the poorest. And drug-makers' R&D pipelines are still skewed toward diseases that affect rich-world patients the most.

Medical matchmakers

The push for equitable access to healthcare is encouraging others in the industry to play their part. Since 2020, Fernanda Furlan and Juliana de Carvalho have been coleaders of a project that aims to build new connections in the pharmaceutical supply chain. "We wanted to do something to improve access to medicines, but we couldn't do it alone. BASF is a major manufacturer of pharmaceutical ingredients, but we do not produce final dosage formulations (medicines) for patients," says Furlan, Head of Quality, RA & Innovation Nutrition & Health – South America at BASF.

The BASF team worked with the German-Brazilian Chamber of Commerce (AHK) to develop a program for a startup operating in the space. After considering ideas from different groups, they found an early stage organization that offered the right fit for its strategy: PegMed.

PegMed – the name comes from the Portuguese verb "pegar," which means "get" – had a compellingly simple concept. "Every year, pharmaceutical companies incinerate large quantities of medicines because they are approaching their expiry date," explains Furlan. "Those products might be good for a year or more, but pharmacies and medical distributors want a longer shelf life than that. The PegMed idea was to find a better use of those medicines, by donating them to NGOs and other organizations that can make use of them in a transparent, traceable and compliant way."

Exact figures are hard to come by, but industry analysts estimate that pharmaceutical companies write off 3 to 7 percent of their inventory every year. That's a significant waste of resources that could be life-changing or life-saving for millions. Conversations with BASF customers in the pharmaceutical industry showed that the idea had real potential. "Companies don't want to destroy good products, but they had no way of finding alternative users for them," says de Carvalho, Digital Innovation Manager at BASF South America.





Over the past year, BASF and AHK have helped to transform PegMed from an idea into a full-fledged product. They have built a digital platform, available as a smartphone app and a website, that matches pharma companies with excess medicine with approved organizations that can use it. By the middle of 2023, five major pharmaceutical companies in Brazil had signed up to the platform, together with more than 70 approved user organizations. "Our users range from very large organizations, like the Red Cross, to small charities offering cancer care for children," says de Carvalho.

There are still things to iron out, adds Furlan, including changes to the way Brazil's taxation system accounts for donated products, but the BASF team expects the platform to go online early in 2024. If PegMed succeeds in Brazil, the team hopes to roll out the approach in other developing nations.

Hidden hunger

Preventing or curing disease doesn't always require a pill or a jab. A bad diet is linked to poor health all over the world, whether that's rising levels of obesity or chronic malnutrition. Like so many other health outcomes, however, the issue is especially prevalent in lower-income communities, where people struggle to access or afford a nutrient-rich, varied diet.

You don't have to be hungry to suffer from malnutrition. The World Health Organization estimates that half of all preschool aged children, and an astonishing two-thirds of women of reproductive age, have diets that leave them deficient in micronutrients: the 27 vitamins and minerals the body requires, sometimes in tiny quantities, to function properly.

Vitamin A

Vitamin A is required for normal vision and the function of the immune system, among other things. BASF is a major supplier of vitamin A and has been supporting food fortification projects in about 40 countries for the last 20 years. Vitamin A is often added to vegetable oils, flour and sugar.

Lack of Vitamin A in the population





In good hands With fully equipped operating theaters and accommodation for its staff of volunteer medics, the Lifeline Express offers a range of health services, from life-transforming surgery to advice on the management of conditions such as epilepsy.



Micronutrient deficiencies are linked with a wide range of health problems, from weakened immune systems and diminished physical capacity to blindness and cognitive impairment. The prevalence of specific deficiencies depends on the characteristics of local diets, but shortages of folate (vitamin B9), iron, vitamin A, and zinc are particularly common worldwide.

Bread booster

One way to improve the availability of micronutrients is by adding them to the staple foods people already eat. This approach has found favor with public health specialists, because it is a costeffective way to deliver benefits at a large scale. Common targets for food fortification programs include salt, cooking oils, flour, milk and sugar.

Mariam Al-Hazaa is Business Development Manager at Al-Hazaa Investment Group, which runs a network of 12 flour mills in Jordan and other countries in the region. In response to high levels of iron deficiency – anemia – in the population, the Jordanian government has operated a country-wide flour fortification program since 2002. The program focuses on the Mowahad wheat flour used to make a flatbread that is a staple in the region. Beginning with the addition of iron and folate to the flour, it has been extended over time to include seven additional vitamins and zinc. The government supplies millers like Al-Hazaa with the micronutrients as a premix, which they blend with the flour during production.

As awareness of the benefits of good nutrition increases among its customers, Al-Hazaa Group has extended its fortification activities to other products. "In addition to our participation in the government program, we also produce a fortified general purpose flour for consumers," says Mariam Al-Hazaa. The company has also worked with commercial customers to encourage the adoption of fortified flours in a wider range of products.

That process hasn't always been straightforward, she says. "Fortified flour needs to be stored in controlled conditions to preserve the micronutrients, and the addition of the premix can affect the color, texture and even the smell of the finished product." Mariam Al-Hazaa suggests that the broader adoption of fortified flour will require attention to the formulation and quality of nutrient premixes, and will require both millers and end users to adapt their processes. Al-Hazaa Group is a founding member of Millers for Nutrition, an industry-led coalition that aims to make fortification of staple foods easier and more rewarding for millers. As founding partner, BASF provides technical expertise and mobile test kits to support millers to achieve fortification excellence.

In Jordan, the prevalence of iron deficiency in children halved in the decade following the launch of the country-wide flour-fortification program. Wider global efforts to rectify health inequalities are making progress too. Yet the gaps in health outcomes remain wide and, in many areas, improvement has slowed in recent years. Closing those gaps will require sustained effort and investment by governments, industry and NGOs. As the examples here show, it will take a little ingenuity too.



We need innovative solutions to improve nutrition."

Mar<mark>ia</mark>m Al-Hazaa Al-Hazaa Group

lodine

lodine plays an important role for many functions of the body. The element is an essential component of two hormones produced by the thyroid gland in the neck: thyroxine and triiodothyronine. These hormones regulate the metabolic rate, activate the nervous system and promote growth and brain development in children. Dietary sources of iodine include seaweed, fish and shellfish. Vegetables, meat and dairy products will contain iodine if they are farmed in an area with enough of the mineral in the soil. About 2 billion people worldwide do not get enough iodine in their food. The most obvious symptom of iodine deficiency is swelling of the thyroid gland, leading to a visible lump on the neck called a goiter. Lack of iodine can have profound health consequences, ranging from fatigue and weight gain in adults to impaired mental function and physical development in children. One way to improve the availability of dietary iodine is fortification: Most commonly, small quantities of iodine are added to salt, which can be used for cooking or as a table condiment.



1 Brain development, function and mood

2 Lungs Breathing rate

3 Heart rate and function

4 Liver function

5 Intestines Metabolism, digestion and energy consumption

6 Reproductive function

Muscles
and bone
growth and
development

 Lack of thyroid hormones can cause
hair loss and dry skin Atomic number 53

Physical state Solid

Occurrence

The 61st most abundant element on the planet, making up less than 0.5 parts per million of the Earth's crust

Discovery

Discovered in 1811 by French chemist Bernard Courtois

Production

lodine can be extracted from seaweed, but most is now obtained from caliche, a sedimentary rock, or from brine drawn from oil and gas fields.

Uses of iodine



Medical assistant lodine is used as an antiseptic, to clean open wounds or to disinfect the skin before surgery.



Colorist lodine is used in printing inks and dyes, producing a range of colors from deep cherry red to rose and blue.



Reaction starter lodine compounds are used as catalysts in the production of many chemical products, from rosin and synthetic rubber to acetic acid.



Fiber stabilizer lodine compounds are added to the synthetic fiber polyamide 6 to improve the stability of material at high temperatures.



Light aligner lodine is used to create polarizing films, which make TVs, computer displays and phone screens brighter and clearer.



Ripeness checker Apple growers use an iodine solution to check the ripeness of their crop. The color of the solution varies according to the proportion of sugar and starch in the fruit.

From pollution to solution

Iransforming excess CO₂ into useful products might sound like science fiction, but it's reality.

Fuel

Using CO₂ to fly in a more climate-friendly way – this is what SAFs (Sustainable Aviation Fuels) make possible. SAFs are obtained from non-fossil raw materials and produce up to 80 percent less CO₂ than conventional kerosene over their life cycle. Various processes and feedstocks are available for their production. However, the quantities produced have so far been low due to the high costs involved. This means that the development of new technologies is now in full swing. We present two innovative routes based on the two alcohols ethanol and methanol.

From ethanol

The U.S. carbon recycling company LanzaTech captures and processes carbon gases from industry before they enter the atmosphere. At the core of its technology is a proprietary strain of the bacterium Clostridium autoethanogenum that consumes waste carbon to produce more climate-friendly versions of widely used chemicals such as ethanol. Ethanol can be used to make textiles, packaging and SAF. While the bacteria can digest CO₂ directly, it considers CO one of its favorite dishes. So, LanzaTech and BASF aim to apply BASF's catalytic process to partially convert CO₂ into CO. This allows the bacteria to feast on the carbon in their preferred form and makes the reaction more productive

From methanol

Thyssenkrupp Uhde, OMV Germany, ASG, DLR and BASF have been working on a methanol-to-SAF project funded by the German Federal Ministry of Digital Affairs and Transport since 2022. Methanol production uses CO_2 from industrial and biowaste gases, as well as green hydrogen. However, bringing the two feedstocks together is a challenge: CO_2 is a very inert gas. BASF Process Catalysts succeeds with a new catalyst to set the reaction in motion anyway, and thus produce methanol – feedstock for the sustainable jet fuel. The feasibility study will continue in the laboratory until the beginning of 2025.

Food

Exhale, then eat: The Finnish startup Solar Foods produces proteins from air – more specifically, from the CO_2 contained in air. It does this by fermentation, similar to brewing beer. In a bioreactor, bacteria are fed with CO_2 , hydrogen, nitrogen and minerals. The resulting slurry is dewatered and then dried, producing a mustard-yellow protein powder called Solein. This can be used as an ingredient in many culinary products – from meat substitutes to pasta and beverages. The powder received regulatory approval as a food in Singapore in 2022, where Solein ice cream has been available since 2023.

solein.com

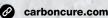
Soap

Carbon sequestration goes sudsy: Canadian soap company CleanO2 has found a way to use CO₂ emitted by gas-powered heaters in hotels and commercial buildings. To capture the carbon dioxide, the CleanO2 team developed a patented machine that connects to boilers and furnaces. It contains potassium hydroxide, which reacts with the CO₂ to form calcium carbonate - also known as pearl ash - a white powder that gives soap and detergents a smooth lather. According to the company, each machine captures as much CO2 per year as 300 trees.



Concrete

Canadian company CarbonCure has developed a concrete solution for carbon dioxide: Its process injects CO₂ recovered from industrial exhaust gases into fresh concrete, where it gets mineralized into calcium carbonate. This is a win-win situation for the climate. It improves the compressive strength of the concrete, so less climate-damaging cement is needed. At the same time, the greenhouse gas is permanently bound in the mineral. The first building components using this specialty concrete have already been installed. Amazon, for example, has worked with CarbonCure on construction projects, including its HQ2 in Arlington, United States.



Perfume

cleano2.ca

What does CO_2 smell like? Nothing, actually. Yet it has still found its way into the perfume industry: The U.S. firm AIR COMPANY captures carbon dioxide from industrial plants before it enters the atmosphere. It then uses green hydrogen to transform this CO_2 into pure ethanol, methanol or paraffins. Exactly how the award-winning patented AIRMADETM

process works is a company secret, but it reportedly mimics the principles of photosynthesis. AIR Eau de Parfum is made by mixing the resulting ethanol with water and essential oils to create a scent with orange peel and fig leaf top notes. The manufacturing process is still very expensive, which is also reflected in the price: A 50 ml bottle costs 220 U.S. dollars.

aircompany.com



Technology & society

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here are hazards everywhere. A walk in the city exposes you to danger from road traffic, air pollution and crime. Yet staying at home on the couch might be even riskier: a sedentary

lifestyle is associated with a range of diseases, from cancer and diabetes to depression. Life requires us to navigate a complex web of risks and rewards, and we don't always get the balance right.

Can individuals learn to manage the risks they face, or should governments, companies and experts do more to protect us from risky situations? We asked four experts to talk to us about the science of risk. A pioneering psychologist explains how our judgements about risk are as much emotional as logical. A risk communication specialist tells us that information can support risk management in public health, or undermine it. A risk manager outlines the systems that help companies manage complex risks. And a BASF scientist illustrates the role that state-of-the-art analytics plays in the safety of chemicals.

may be used to assessing risks in an analytical way, using research, data and statistics. When we started our research on risk perception, we expected to find

Do people understand risk?

on risk perception, we expected to find that everyone used a similar, if simplified, version of that approach. But it turns out that most people evaluate risks through their feelings. They think about the situation and the way it's described to them, and that generates a feeling in them of worry, anxiety, fear or hope. And those feelings and emotions are the representation of risk for them.

The things that we fear most are often

the things that we are most unlikely

If you are an expert or a scientist, you

to experience, like plane crashes.

Why and how do our emotions influence the decisions we make?

Our emotional responses have been amazingly valuable for us since our earliest days as an evolving species, not only for judging risks but also for managing our lives. Consulting our feelings first gives us a mechanism to make rapid decisions: Should I drink this water? How should I react to that noise? We call that mechanism the "affect heuristic."

How does the affect heuristic determine our response to modern-day risks?

Various factors beyond simple statistical likelihood have a strong influence on people's emotions and their risk perceptions. Are you exposed to this hazard voluntarily or involuntarily? Can you control your exposure, or is it not in your control? Is the impact of the hazard immediate or delayed? How big is the reward I expect for taking this risk?

Can you give examples of risks that people perceive differently according to the context?

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Take medical X-rays and nuclear power. They are both technologies that involve radiation, but people see the former as being controllable, well-understood and offering a high benefit, so they perceive the risk as low. By contrast, people looked at nuclear power with a sense of dread in the early days of the industry. Nuclear accidents could have catastrophic consequences and the benefits were not very clear, so they perceived it as a highrisk technology. An example of changing perceptions is smoking. The health

Dr. Paul Slovic

is a psychology professor at the University of Oregon, United States, and President of Decision Research, a consultancy. He studies judgment and decision processes with an emphasis on decision-making under conditions of risk. impacts of smoking have been known for a long time, but people perceived it as a voluntary hazard. In the 1990s, when the evidence for passive smoking became clear, people began to think about smoking as an involuntary hazard, which paved the way for the restrictions we have today. The study of risk perception has enormous importance for the communication and interaction between experts and non-experts.

If our risk perceptions are driven by emotion, can we rely on scientists to help us make judgements?

There is the idea that scientists deal with objective risks – such as the number of fatalities expected from the use of a certain technology – while the public perception is subjective, and somehow irrational. But those so-called objective calculations are subjective too. They give equal weight to all manner of differences: whether the person was young or old, whether they were doing something voluntarily because they enjoyed it, or whether it was imposed on them by a company that was gaining all the benefit.

A lot depends on whether people trust the scientists. Nuclear power was accepted more readily in France than in the United States, for example. Not because people didn't fear the risks, but because they had greater trust in the authorities to manage those risks.

What do we still have to learn about risk perception?

One big area is the interactions between the different ways our minds handle risks. Risk is something we can calculate and analyze logically in a slow way, but that process interacts with other mechanisms in our brain that operate in milliseconds without deep thought, and yet create feelings which are very powerful. We call that the dance of affect and reason. We don't realize that our own minds deceive us about risk because they generate feelings that mislead us.

Do experts such as governments, public health institutions and medical professionals do a good job of communicating risks?

Risk communication plays a vital part in many institutional settings, more so today with the threat of misinformation. Allocating time and resources to risk communication training and education for experts, policymakers and health professionals can be a vital way to improve the way they interact and engage different groups of people. Beyond communicating risk, experts should also think about what access and levels of information different audiences have. Filling in the informational gaps can not only help people understand risk in their own context, but also empower them to make informed choices in situations where they may not have access to healthcare professionals or institutions.

Can you give an example of successful risk communication efforts in the field of public health?

One example was the initial outbreak of COVID-19 among migrant workers in Singapore. A lack of consideration of language barriers and understanding of migrant communities were just some factors which contributed to this. However, once these and other gaps were identified by local authorities, appropriate strategies were implemented, including providing multilingual health information and disseminating information across various channels including social media, and working with community leaders of different migrant groups.

Do risk communication efforts sometimes go wrong?

An example of poor risk communication was Australia's use of a fear-centered video campaign to communicate the importance of getting vaccinated against COVID-19 in July 2021. The health authorities recommended mRNA vaccines to young adults. However, there was a shortage of the vaccines during the campaign. This resulted in increased anxiety and panic, especially among young people, instead of the intended adoption of the vaccination.

The risks we must consider in our lives – how are they changing?

Focusing on health, we are living in a dynamic world, and our health has undeniable links to the climate and the environment we share. For example, rising temperatures may increase the transmission of diseases such as malaria. Conversely, modern medical advances mean there are new possibilities when it comes to reducing the risks related to certain illnesses. As society progresses and our knowledge increases, we must accept that the risks are also progressing. Information is power. In order to stay one step ahead of evolving risks, people need to keep abreast of the happenings in the world around them. It might seem an impossible task but thankfully, access to knowledge has increased dramatically.

In a fast-changing world, what can we do to make better decisions?

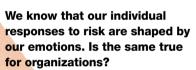
Accessing information from reliable sources and keeping informed on the changes of the world is essential for us to update our understanding of risks in our life. At the same time, we must be mindful about an infodemic – an excessive amount of information about an issue that is typically unreliable, spreads rapidly, and makes a solution more difficult to achieve. An over-exposure of information from different sources with varying reliabilities may lead to unfavorable outcomes such as confusion, anxiety and stress.

Dr. Yiyun Shou

is Lead Scientist at the Lloyd's Register Foundation Institute for the Public Understanding of Risk at the National University of Singapore. Her research focuses on attitudes toward risk in health and medical settings.

The health communication specialist

Beware the infodemic



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The challenge for organizations is alignment. The culture of an organization shapes the organization's "risk appetite" and its response to risk. That is decided by senior management with influence from the wider ecosystem, such as their customers or industry regulators. But it's the actions of key individuals in the organization that shape the behavior of the company, and they may have a very different risk appetite. We've seen that happen in the banking sector, where risky actions by one individual can lead to significant financial losses.

How can organizations ensure that all their staff manage risks appropriately?

Good risk management should be integrated into an organization's management systems. We call that enterprise risk management (ERM). Individuals work on projects or within departments, but the organization is interconnected, and the ERM system needs to account for that. For example, a single project in an organization might adopt a certain approach to manage the risks associated with a supplier. The approach might be very different if the same supplier provides critical parts for a dozen other projects across the business.

Organizations face a lot of scrutiny from governments, the public and other external stakeholders. Should they do a better job of communicating their approach to risk?

Transparency is fundamental to strong risk management. Some of the best examples of that come from the safetycritical industries, like aerospace and the nuclear and chemicals sectors. These industries have rigorous processes and a culture where they continually try to learn from mistakes and share those lessons so that they are not repeated. Aerospace companies share details of incidents and accidents in public reports, for example, so the whole industry can benefit from the lessons learned. Other industries, such as the financial services sector, could consider following this example.

What role do new technologies have to play in effective risk management?

Technologies come with their own risks, such as increased susceptibility to cyber-attacks. But they can also be an enabler of better risk management. At its heart, risk management is about decisions. Digital technologies give you better data, and better tools to turn that data into information that supports effective decision-making.

What advice would you give to a CEO who wanted to improve risk management in their organization?

I would say, never forget that risk management is about people and culture. If the people in the organization don't recognize that understanding and managing risk is an integral part of the decision-making process, then the organization will only ever pay lip service to risk management. Companies should establish a dedicated risk management office, with expert facilitators, coordinators, mentors and managers, whose job it is to help those in the rest of the organization develop the skills and culture they need to manage the risks they face.

is Associate Professor and Managing Director at the British University in Dubai's Centre for Risk and Innovation and board member at London's Institute of Risk Management. She previously worked on the development of risk strategies at Rolls-Royce.

The chemist

Innovate responsibly

The use of chemicals is debated with high emotions in public discourse. Should we ban harmful substances?

Chemicals are used for a reason: They are enablers to achieve a desired function or performance feature in a material. It is the reactivity that make these chemicals so useful, but it can also pose hazards to health and environment when the reaction is not limited to the intended and controlled situations. We need reactive chemicals for innovative materials - not least to progress in climate protection and energy solutions. Isocyanates in polyurethane foams insulate buildings, thus saving energy and cutting CO₂ emissions; epoxy hardeners increase the durability of windmill blades for green electricity; and what are called cathode active materials make it possible to switch to sustainable mobility with longer-range batteries. For all this, manufacturers and professionals need the full chemical toolbox with substances we know how to handle safely.

Consumers are very sensitive when it comes to chemistry – be it in cosmetics, home cleaning products or toys. How do you see this?

As consumers we want to protect ourselves and our families. At the same time, we are seeking certain functions in products. They should be durable or easy to use, help us to save energy or protect us. As chemists, we are used to looking at both sides of the coin: which substances will help us to develop these functions and how can we make sure that the user is safe. Our advanced analytical methods, with which we can, for example, determine substances back

Dr. Carla Seidel

is Senior Vice President Analytical and Material Science at BASF. She is a member of the Board of the German Chemical Society and of the Board of Trustees of the Bundesanstalt für Materialforschung und -prüfung. to the ultra-trace level, help us to do this. Before new chemical substances come to market, we subject them to all necessary environmental and toxicological tests and apply to the appropriate authorities for registration.

How can you use something hazardous in a safe way? Isn't that contradictory?

Stairs are a simple example. If you are planning a house, it is difficult to do without them, even if they are associated with a risk of falling. However, you can install non-slip steps, fit a handrail and ensure good lighting, for example. This is risk management: Establishing the evidence about the hazard and deriving measures for protection. The ban itself is not the solution – managing the risks responsibly is!

How is the assessment of chemical risks evolving?

The industry is always working to create innovative solutions that are more effective. less hazardous and more resourceefficient. Already more than ten years ago, we at BASF started to develop a method called Sustainable Solution Steering -TripleS. We use it to manage our portfolio, evaluating how well each product meets the requirements of customers and regulators. A product that does not fulfil the criteria will be phased out within five years. This is a continuous effort, as scientific knowledge progresses and legal requirements evolve. We've recently extended the TripleS methodology to consider how products support even wider sustainability goals.

What would be the consequences of banning chemicals?

Banning chemicals outright – even if they are only used in small quantities as intermediate products in production, or for research – will limit innovation. This would be fatal at a time when innovations are needed to cope with numerous sustainability challenges, from the energy transformation to carbon management and the circular economy. To solve these challenges, the world needs chemicals more than ever.

All-around protection

Whether it's car theft or crop damage – there are many things from which you can protect yourself and others. And many ways to do it: We introduce you to smart ideas from around the globe.

Sun hats for pineapples

Malaysia, USA Just like humans, pineapples can suffer from sunburn. In the worst case, too much sun can destroy a whole pineapple harvest. The Malaysian recycling company 3T Industries and BASF protect the fruits with sheets made from 100 percent recycled polyethylene. The sheets block direct sunlight without impairing photosynthesis, allowing the plants to thrive undercover. A BASF additive improves quality and weather resistance of the pineapple's sun hat. The UV protection works on water too. At BASF's site in McIntosh, United States, a floating solar system – developed in partnership with Noria Energy – is protected with plastic additives produced on site.





Protecting species from space

South Africa The African elephant is one of the biggest living creatures in the world – an advantage for the endangered species. A British-Dutch research team has succeeded in using Al-based recognition software to count elephants in the bush in Addo Elephant National Park from space. This is a glimpse of hope for endangered species. To protect them, information about their population trends and their location is crucial. With the help of algorithms, even large, hard-to-survey areas can be scanned in a short time.

øbit.ly/space-elephants





Helmet for hand luggage

Spain Bicycle helmets can save lives. If only they were not so bulky and unflattering. The Spanish company Closca is changing this. Their collapsible helmet can be folded down to half its size, thanks to

a patented system. This makes it easy to fit in a backpack. The eye-catching design was inspired by the curved shape of the Guggenheim Museum in New York and has already won a number of awards.

🔗 closca.com





Unshakeable

Japan, USA Earthquakes cannot be prevented from happening, but the collapse of a building often can. This fact drives architects in Japan, in particular: Nowhere else in the world are there as many earthquake-proof buildings as there are here. This is achieved by, for example, cross braces that vibrate during tremors, steel balls on the roof that reduce oscillations in the upper stories, and floating surfaces that cushion earthquakes. This inspired the U.S. company Apple for their headquarters in the Silicon Valley: A sliding mechanism made of around 700 large, saucer-like elements between the foundation and the floor ensures that the building can move horizontally by about one meter in each direction. This cushions approximately 80 percent of oscillations, since the building is decoupled from the ground.

Your face is the key

Germany The BASF startup trinamiX has developed an innovative solution for the car cockpit in collaboration with the automotive supplier Continental. The Driver Identification Display works by facial recognition like the unlocking of a smartphone. It identifies the owner with the help of a built-in camera, and thereby allows the engine to start. During the journey, the camera observes the driver's attentiveness and focuses on their driving safety. A warning system can respond to tiredness and inattentiveness and thus prevent accidents. In the future, it will also be possible to pay via facial authentication – for example, in parking garages.



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Artificial intelligence could allow you to do things that just weren't possible before."

Associate Professor Ricardo Vinuesa Department of Engineering Mechanics, KTH Royal Institute of Technology Stockholm, Sweden

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Can Al fix the planet?

Humans are struggling to address big sustainability problems. Maybe machines could do a better job.

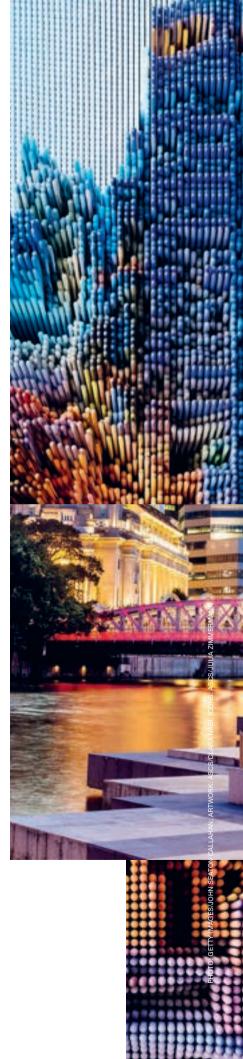


very year, human activity sends around 350 million tons of methane into the atmosphere. The gas traps heat, driving roughly one-third of the global temperature increase since the Industrial Revolution. And while carbon dioxide emissions are an inevitable

byproduct of fossil fuel combustion, much of that spilled methane is the result of bad management. In addition to distributed sources, such as agriculture, a large amount of the powerful greenhouse gas is vented in high concentrations from oil wells, leaks from pipelines or seeps from landfill sites. Stopping those emissions would help to slow global warming, but tracing a fugitive plume back to its source is a complex and labor-intensive activity. It can take multiple data sources and many rounds of analysis to pinpoint the root cause of a methane problem.

Eye in the sky

There might be a quicker way. Peter Joyce, PhD, and his colleagues from the U.K. National Centre for Earth Observation have shown that artificial intelligence (AI) technology can identify and quantify methane emissions from satellite images. They used weather



modeling software to create simulated images of methane plumes of different sizes, then trained an AI system to recognize them. Once the system knew what it was looking for, they applied the approach to real-world data. The approach proved faster at finding and evaluating methane plumes than conventional methods, requiring only around a minute to spot 21 plumes in satellite images covering 900 square kilometers.

Methane spotting is just one of hundreds of challenges we face as we seek to better understand – and mitigate – our impact on the planet. From measuring changes in the extent of sea ice or ocean garbage to assessing the health of forests or predicting variations in local air quality, environmental problems are characterized by large volumes of complex data and significant uncertainty. Crunching that data is laborious and difficult for humans, but might be quick and easy for a well-designed AI system.

Beyond helping us to understand the world, artificial intelligence could also help us do a better job of running it. It is not only able to monitor and predict developments, but also to make recommendations and decisions. And the world urgently needs better decisions. In 2015, the United Nations agreed its 2030 Agenda for Sustainable Development, a list of 17 Goals and 169 Targets designed to improve health and education, reduce inequality and spur economic growth, while tackling climate change and

Al contributes to greater resource and energy efficiency."

Dr. Andreas Wernsdörfer Head of Digitalization of Production and Technology at BASF working to preserve oceans and forests. At a 2023 summit marking the midpoint of the agenda's planned implementation period, UN Secretary General António Guterres warned that the world is on track to meet only 15 percent of those targets, with "many going into reverse."

In a widely cited 2020 article in the journal Nature Communications, a team from KTH Royal Institute of Technology in Stockholm, Sweden, evaluated the likely impact of AI on the Sustainable Development Targets. They found that AI had the potential to act as an enabler in efforts to meet 134 of those targets, almost four-fifths of them.

"We identified many areas where AI could allow you to do things that just weren't possible before," says Ricardo Vinuesa, Associate Professor at the Department of Engineering Mechanics and one of the study's lead authors. "For example, you can use AI to analyze satellite data and identify regions where crops are failing and the risk of extreme poverty is increasing, then try to coordinate actions to help those areas." Other areas with significant potential include the use of AI to optimize the complex interactions between supply and demand in energy networks dominated by renewable electricity, or the management of transport flows in digitally integrated smart cities.

Waste not

That's the theory. What's happening in practice? While AI chatbots are making headlines around the world, other systems are getting on with less glamorous jobs. Several countries, such as the United States, Great Britain, Germany, Japan or South Korea, have begun to adopt AI technologies to optimize waste management, for example. Al can not only do a notable job in sorting and separating waste, but also in planning routes and schedules for refuse collection. Fill level sensors in the bins monitor the amount of waste and show whether a collection is necessary. This reduces emissions and traffic congestion caused by collection vehicles. In Punggol Digital District, a new business and research park in Singapore, one of the world's first large-scale smart energy grids is under construction. Buildings in



An expensive education

Al technology comes with environmental costs as well as benefits. These technologies can be cheap and efficient in use, but building them requires significant resources.

Learning on the job Neural networks are not programmed like a conventional computer system, they are trained. That involves feeding the system with millions of example problems, and gradually tuning its connections until it produces good solutions most of the time. Finding, or creating, enough data to train the

model is a key challenge

in AI development.



Power hungry

Teaching an Al is resource-intensive. OpenAl's GPT-3 system used an estimated 1,287 MWh of electricity in training, and generated 552 tons of CO_2 emissions. That's more than 70 times the annual emissions of the average E.U. citizen. Developers are working on Al models that learn faster or need less retraining.

the district will be able to communicate with the system and intelligently adapt their power consumption in response to changing conditions.

Finnish telecommunication equipment maker Nokia, meanwhile, has developed an Al tool to improve the energy efficiency of mobile data networks. The system analyzes and forecasts demand on radio towers and computer systems, automatically adjusting or shutting down equipment at times when data traffic is low. The company claims that its approach can reduce energy consumption and CO_2 emissions in mobile networks by up to 30 percent. That's two to five times better than the savings operators achieve with conventional methods.

The chemical industry is pursuing AI-powered efficiency too. BASF has been gradually digitizing its Verbund integrated production sites for decades, for example. The construction of the company's new facility in Zhanjiang, China, is giving it

Zero leftovers

Restaurants are

adopting Al technology to cut down on waste. The Winnow system uses an Al camera to identify food scraps as they go into the bin. Staff tell the system why the food was thrown away and managers can use the resulting data to fine-tune portion sizes, recipes and purchase quantities.

Al can also help **consumers** make better use of whatever is left in their fridge. Services such as DishGen and Plant Jammer use Al technology to generate recipes based on the

user's preferences and the ingredients they have at hand.

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dishgen.com plantjammer.<u>com</u> the chance to build a site that is designed to be digital from the start. "Al contributes to greater resource and energy efficiency and thus to sustainable operation," says Dr. Andreas Wernsdörfer, head of Digitalization of Production and Technology at BASF. "This will help to make Zhanjiang Verbund site the chemical complex with the lowest carbon footprint in the world." To achieve this goal, BASF collects large amounts of real-time site data to create transparency across the entire Verbund. "In the future our digital tools will ensure full traceability of when and where a renewable material was deployed throughout the value chain. Al algorithms will then be used to simulate which measures the site operations teams can take to contribute to higher carbon reduction, like, for example, exact process and control settings in the production facilities," says Wernsdörfer.

Down in the weeds

Elsewhere, farmers are using data and Al to improve yields while reducing carbon emissions and saving supplies. ONE SMART SPRAY by BASF Digital Farming



and Bosch, for example, uses image recognition technology to automatically recognize weeds growing in row crops. The weed management system works in milliseconds, targeting and delivering herbicide precisely where it is needed. This allows maximum herbicide savings.

Agricultural AI is helping farmers see the bigger picture too. Heinrich Esser is from the sixth generation of his family running a farm in the small town of Vettweiß-Kelz in western Germany. The land produces cereals, potatoes and specialty crops such as asparagus or strawberries. "It is very important to us to cultivate the farm and our fields in such a way that future generations can also make a living from it. We live not only from nature, but also with nature," says Esser. That means pursuing strategies that optimize yields while controlling the use of water, fertilizer and crop protection products. At 150 kilograms of CO_2 equivalent* per metric ton of wheat, Esser's crop has around half the carbon footprint of the average German farm.

Artificial intelligence

But he wants to do even better. In 2022, his farm became a test site for the new Climate Partner Agriculture project from BASF and Raiffeisen Waren-Zentrale Rhein-Main, one of the biggest agricultural wholesalers in Germany. "Over the coming years, trial plots on our farm will test different cultivation strategies aimed at cutting carbon emissions in wheat production by 30 percent," he says.

The approach has digital and AI technologies at its heart. BASF's agronomic decision support platform xarvio® FIELD MANAGER, which is available as an app, provides timely recommendations to optimize crop production. This includes what to do with the crop, how much to do, and when to do it, plus advice for sowing, fertilization, and crop protection use. The Climate Partner Agriculture project is now being extended to other farms.

All good?

Speaking from his office in Stockholm, Ricardo Vinuesa wants to make it clear that the AI revolution brings sustainability risks as well as benefits. "We found that only 35 percent of the UN's Sustainable Development Targets might be negatively affected by AI," he says. "But even one target negatively affected is something to worry about, because the cascading consequences can be unpredictable."

Many of the risks stem from the choices people make in their application of AI, he explains. Al optimization of industrial production could be designed to reduce costs, while ignoring the resulting pollution, for example. Inequality of access could also create challenges, he adds. Al technologies might exacerbate the gap between rich and poor, as the benefits of new tools accrue to the wealthier

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Al must be part of a broader strategy that includes policy change, education, and international cooperation."

ChatGPT Large language model

regions, industries and companies that can afford to develop and deploy them.

There's also a risk that people put too much faith in the ability of these technologies to solve tough sustainability problems. When analysts at consultancy PwC assessed the use of AI in environmental applications, they found opportunities to boost global GDP by 3.1 to 4.4 percent, while reducing carbon emissions by 1.5 to 4 percent. That's nowhere near enough to take the world to its net zero target.

Even leading Als are cautious about their own potential. "Al can be a powerful tool to aid human efforts in environmental conservation and restoration, but it must be part of a broader strategy that includes policy change, education, and international cooperation," says large language model ChatGPT. Vinuesa agrees. He is convinced: "A better understanding of the capabilities and limitations of Al – by industry, governments and the wider public – will be key to exploiting its potential."

Making a clean start

In Santa Marta, Colombia, six women are innovating their way to a better life by creating and selling their own range of environmentally friendly cleaning products.





Mayerlin De La Cruz, Association Treasurer A single mother from the Island San Andrés, she earns some extra money for her two young children by selling soups.





aría Alejandra Torres is from a family displaced by violence. She was born in the Colombian city of El Banco, but when armed groups killed one of her cousins, her father took his family to

Venezuela in search of a safer life. From the age of five, Torres grew up on a Venezuelan farm. She married young and gave birth to a daughter in her teens, juggling motherhood with farm work. After the relationship with the girl's father broke down, she struggled along as a street painter in Caracas.

Torres met and married another Colombian émigré, and the couple had two sons together. Five years ago, their youngest child needed medical treatment. Unable to obtain the care they needed in Venezuela, the family made the decision to return to Colombia, moving to her husband's family home in Vereda El Mosquito outside the coastal city of Santa Marta.

With her son's health improving, Torres was determined to turn her own life around. Despite her children's teasing, she completed her high school diploma and obtained a technical bachelor's degree. And she looked for better work. It wasn't easy to find. Vereda El Mosquito is a poor community. Like Torres, many of its citizens have fled violence or poverty elsewhere. She took a job cleaning in a school, and became involved with a short-lived egg-production business.



Delfina Bolaño, Associate Mother of two grown-up sons, she moved to Santa Marta in 2009 and worked as a domestic servant for ten years.

Meyvilis Cantillo, Associate Grew up on a farm in rural Magdalena. Her family moved to Santa Marta when she was ten in search of a better life.

In May 2022, Torres found the break she was looking for. She joined several other local women with similar backgrounds in the Empowered Women Association (EWA), a BASF-supported social enterprise that has developed a range of environmentally friendly cleaning products targeted at commercial users, especially the hotels and hospitality businesses dotted along Colombia's Caribbean coast. When EWA incorporated itself as a formal organization, her colleagues elected Torres as Association President. "I don't just want a job," she says. "I like to learn. I like to go out and talk to people. I want to get ahead."

In August 2023, the women opened a store in Vereda El Mosquito, which acts as headquarters,

warehouse and retail premises for the growing business. At launch, the EWA's product range included a multipurpose cleaner, dishwashing soap, laundry detergent and a grease remover. Supply contracts with individual hotels and hospitality groups are in negotiation.

From the project's start to where it is today has been a long path. Not everything went smoothly. Some women have left the group to pursue other work, but those who remain are committed for the long term. "I say, what is easy goes quickly," says Torres. "It has been hard work, but we have learned so much in this project, and I believe 100 percent that it has changed our lives for the better."



works away in Bogotá.

<complex-block>

Santa Marta,-Colombia

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The Empowered Women Association is proudly supported by BASF Colombia.

In the early days of the project, BASF experts led training sessions and assisted with the formulation and branding of the new cleaning products. As the women moved from planning to production, BASF continued to help by providing a key ingredient – its environmentally friendly Soluprat liquid soap – and identifying a contract manufacturer with the capacity to make the first commercial batches of their products.



 Used cheese packaging enters the recycling loop.

 It is crushed and then stirred in a solution at 80 degrees Celsius.

 Its components are separated into their individual types and can be recycled.

Happily ever after?

About sticking together and letting go. And where cheese packaging comes in.

ood for creating bonds and making them last, but challenging companions at life's end. That's adhesives. Here's why their breakup is important for a happy ending.

Whether it's for electronic devices, furniture, bottle labels or food packaging, adhesives are used in almost every area of daily life. Modern adhesives are usually made of natural or synthetic polymers, which provide a strong grip. Once materials have been "bonded" with an adhesive, to use the technical term, they can be difficult to separate. An advantage for a product's durability, but challenging for subsequent recycling. To reuse the various materials, they must be separated from each other. This applies particularly to plastic packaging, such as cheese packaging or bags used for chips or pet food, as they are composed of a variety of bonded materials, such as paper, plastic film or aluminum foil. Therefore, they often end up in landfills or are incinerated instead of being recycled.

Keeping packaging materials in circulation drives both policymakers and industry. According to the E.U. Green Deal, for example, packaging in the E.U. must be recyclable in the future. If this is considered during the product development and design stage, adhesives may be the solution. Researchers are developing innovative adhesives that can be removed in the recycling process almost "at the push of a button."

Working with packaging suppliers, recyclers and manufacturers of sorting machines, BASF has developed a new adhesive for cheese packaging. It is water-based and ensures that the composite of plastic film types can be easily separated. This allows for the individual components to be sorted and reused.

Change needs everyone

About 110,000 BASF employees in 90 countries are teaming up with customers and partners to create a sustainable transformation in the chemical industry. Climate protection is a priority for everyone – no matter where they are or what they do. Meet Claire: A production engineer at our site in Wyandotte, United States, Claire founded a community to drive sustainability in manufacturing. She is developing a CO_2 reduction roadmap and conducts regular walks through the plants to identify how they can run more sustainably – consuming less energy, producing more efficiently and using low-emission technologies.



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