MATERIAL FUTURES

Surfaces that respond to stimuli, surroundings that self-assemble, building blocks that reproduce themselves: materials are getting *seriously* smart. In this issue's Frame Lab, we explore alchemic approaches and their chances of surviving the wider world, and uncover five directions for tomorrow's materials.

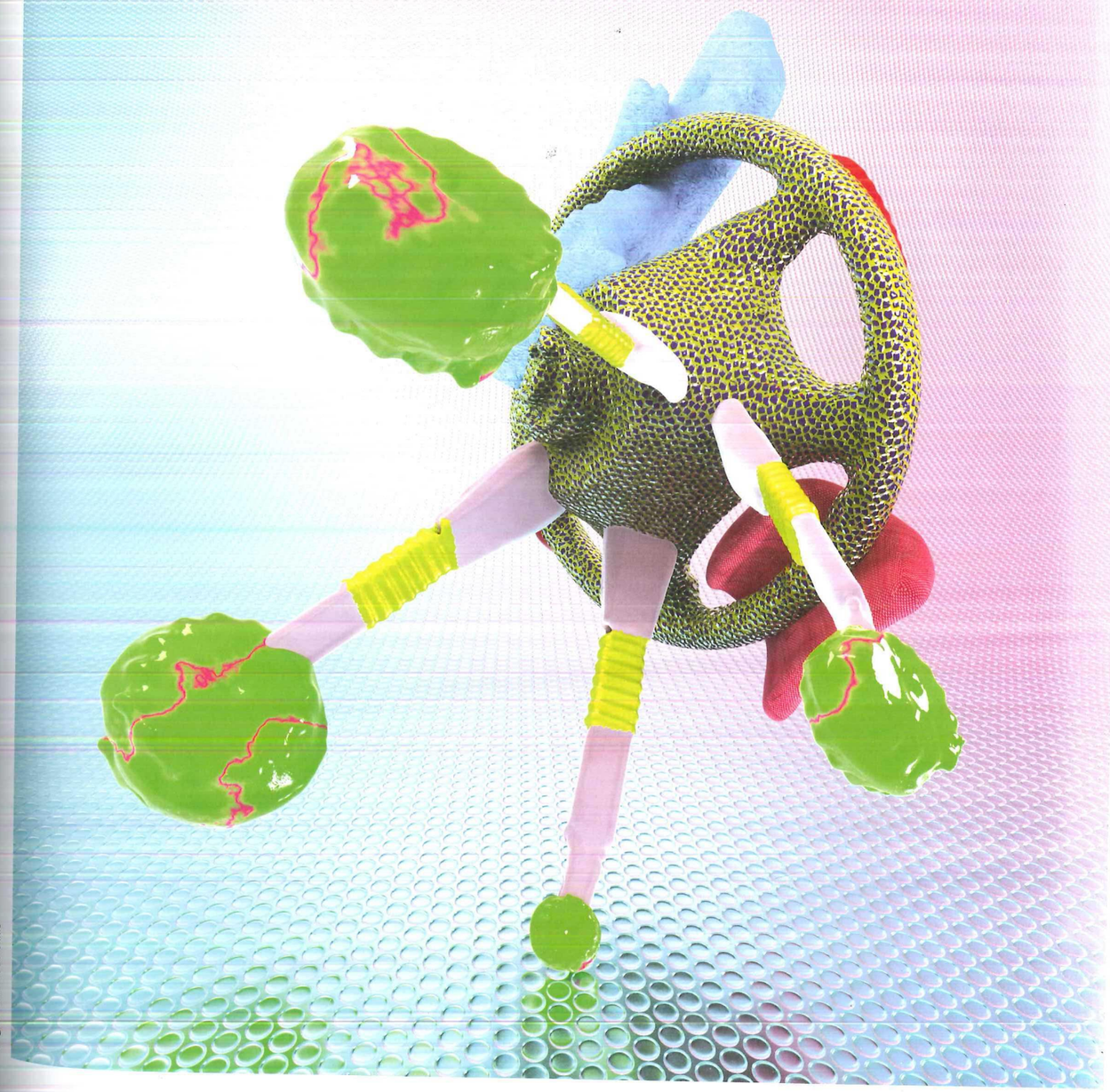
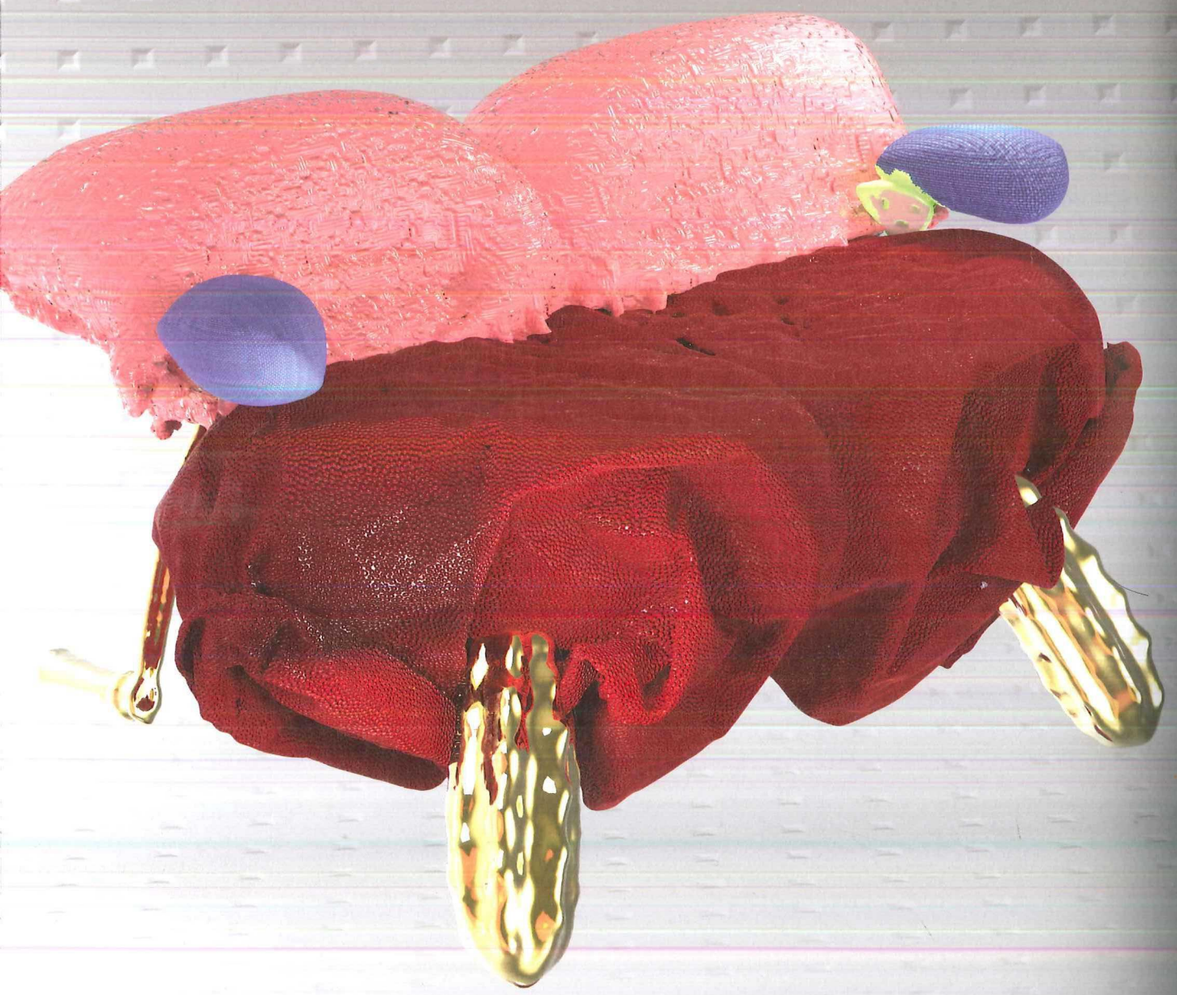


Image Bastiaan de Nennie



TOUCHY SUBJECT

Explorations into materials abound in the design-student realm, but can such alchemic approaches survive the mainstream market? Jonathan Openshaw investigates.

WORDS *Jonathan Openshaw* **IMAGES** *Bastiaan de Nennie*

IN many ways, our lives have never been more immaterial. We use technology to outsource basic human functions that previous generations would have committed to memory, and send vast quantities of digital correspondence with little connection to the physical infrastructure these emails and TXTs will pass through.

Even as our daily lives threaten to dissolve into clouds of data, however, there's been a resurgence in the most tactile forms of human culture. The future of the mainstream music market may be Spotify and Apple Music, but vinyl is also growing 40 per cent year on year. Netflix and streaming torrents have never been more popular for watching films online, but immersive theatre events are also breaking box-office records. Innovative websites and retailers may be putting contemporary art online, but they cannot replace the physicality of standing in the Tate Modern's Turbine Hall.

When used well, digital technology can have a profound decluttering effect on our lives and leave us free to appreciate the material world around us in new ways. This is also evident in the quiet renaissance in materials studies taking place across design, art and architecture. People are more interested than ever in where an object came from, how it was made and to which stories the object can connect them. This shift in mind-set is driving advances in materials, from radically repurposing waste plastics to making precious luxury objects out of challenging raw materials such as human hair and beetle carapaces.

The luxury industry was built on a deep appreciation of materials, but innovation has been largely stifled by a sense of heritage in recent years, with brands returning to their archive for inspiration and prioritizing so-called noble materials such as silk, marble and bronze. 'Luxury cannot just reside in the past. It is fundamentally rooted in change, in relation to innovations in technology and science, but also as a reflection of societal values,' explains Leanne Wierzba, who co-curated the V&A's major exhibition What Is Luxury? earlier this year.

Noble materials derive their power from tradition and from established ideas of value. They are also very much rooted in place – Carrara marble, Italian silk, the discrete tick of a Swiss watch. 'With globalization, this sense of place has become increasingly distorted. Materials innovation can provide an opportunity for relocating materials in time and place, and can give rise to new types of storytelling within established fields,' says Wierzba.

For the last decade, luxury may have been equated to heritage, but for the next decade it may be much more about legacy. More about innovation than introspection, helping people to understand and explore their place in the world.

The V&A exhibition featured a number of designers championing a legacy approach to luxury, one being Anglo-Japanese Studio Swine. Cofounded by architect Azusa Murakami and artist Alexander Groves, the studio has made its name through extraordinary processes involving materials. 'Focusing on materials is the best way to drive innovation,' says Groves. 'If you lead with set ideas of form then it's quite easy to get stuck, but if you're focused on resources then you're investigating your place in the world, and how to make undesirable things desirable through design.'

Swine is certainly not afraid to work with 'undesirable things'. Its V&A exhibition was a series of objects that looked like highly polished tortoiseshell but were, in fact, made from lacquered human hair (*Frame* 100, p. 244). Another Swine project showing in London this summer was Gyrecraft (see page 042), commissioned by Selfridges department store. Highlighting the great garbage gyres that collect at the heart of the world's oceans, Swine transformed reclaimed oceanic plastic into a series of five totemic objects, each drawing design references from local cultures. 'The Anthropocene throws up new resources and imperatives,' says Groves, referring to the current era in which humans seem to be altering the earth on a geological scale. 'We wanted to harvest man-made plastics from the sea as if they were natural resources, in the same way that we historically took whales from the sea to use their oil.'

Matteo Fogale and Laetitia de Allegri applied a similar mind-set to their Denimite collection (*Frame* 102, p. 198), presented at London Design Festival last year, which has the aesthetic of polished marble but is made from recycled denim, cotton and paper. Spanish designer Jorge Penadés also tackled industrial waste in his recent Industrial Skin collection (*Frame* 104, p. 067), which uses compressed leather offcuts to create structural objects, emphasizing the fact that 40 to 60 per cent of raw leather ordinarily goes to waste. For her aptly named Material Illusions project (*Frame* 100, p. 065), London-based Sophie Rowley combines materials such as waste glass from a glazier and polystyrene foam to make sleek and durable objects. ↳

MATERIALS INNOVATIONS PREVIOUSLY DISMISSED AS ART-SCHOOL PROJECTS COULD BE BIG BUSINESS

There's no shortage of these alchemic approaches to design coming out of institutions such as the RCA and Design Academy Eindhoven, but whether they can gain traction in more commercial settings has always remained unclear. Former worldwide director of Phillips de Pury's retail operations Brent Dzekciorius set up his materials-innovation consultancy and incubator Dzek in response to this exact question. 'So many of the designers I was working with in the collectables market were making fascinating material investigations that lived and died within the project at hand. They were never given the opportunity to take things further and to see if these materials could truly impact architecture and design.'

Dzek's first project was with designer Max Lamb, who has built his brand on a materials-focused approach. Dzekciorius describes himself as an editor and instigator who asks questions of the designer he's collaborating with rather than trying to provide answers, and who uses his connections with bigger brands and industry to leverage their work. The outcome of the Dzek x Lamb collaboration was Marmoreal (*Frame* 98, p. 042), a composite terrazzo stone made out of offcuts from industrial construction projects. 'There's a strong sustainable slant, because it's additive rather than subtractive. You make exactly as much material as you need for that project,' says Dzekciorius, who is currently working with Tom Dixon and Amsterdam-based Italian design duo Formafantasma on new materials projects.

Initiatives like Dzek are making headway in connecting cottage-industry discoveries with big business, but transforming complex and expensive industrial processes is still a huge challenge. 'You'll find very few big companies who are willing to take the risk,' says Dzekciorius. 'They operate closed systems that are carefully optimized and often overseen by technologists or scientists who have little interest in radically new design. Their system is working well, so why risk the costs of failure?'

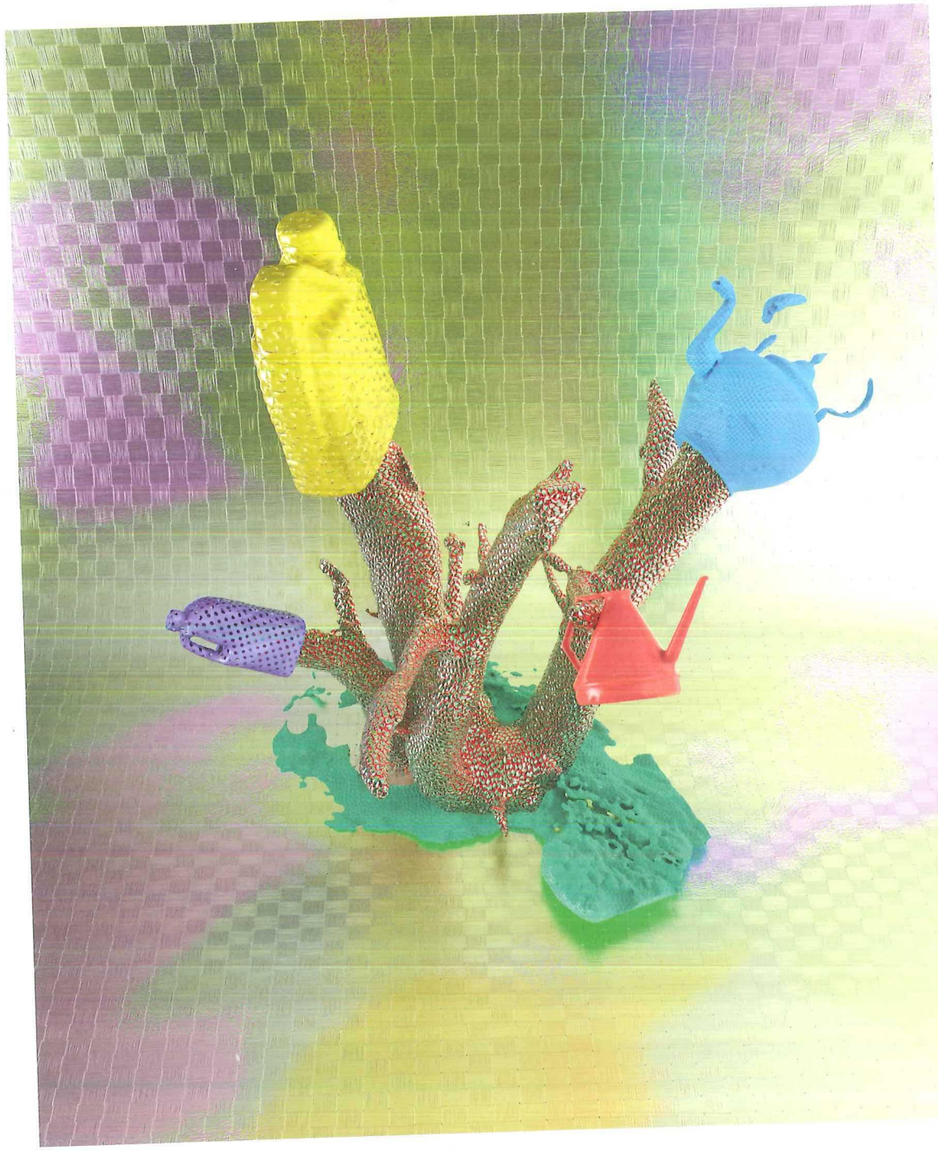
Shifting sensibilities among younger consumers may be poised to break this impasse, meaning that materials innovations previously dismissed as art-school projects could be big business. Nike turned the unglamorous internal process of materials sourcing into a major selling point with the release of its Making app back in 2013, open-sourcing the brand's Materials Sustainability Index (MSI) and giving external designers a detailed breakdown of the hidden costs of various materials.

The sportswear market is one of the fashion industry's great success stories of recent years, with market research firm NPD Group charting growth of 9 per cent last year to nearly US$35 billion. The sector's materials-focused mind-set seems to be resonating with a millennial consumer who is more interested in the new than in the traditional. Nike's long-term sparring partner Adidas has recently broken new ground with its reclaimed oceanic plastic-trainer prototype, made in collaboration with Parley for the Oceans, which had previously worked with G-Star Raw on Bionic Yarn denim (*Frame* 101, p. 207). Similarly, Coca-Cola has teamed up with pop star and philanthropist will.i.am to launch Ekocycle, a brand that focuses on taking new concepts in sustainable materials mainstream.

Kering Group, owner of iconic luxury brands from Gucci to Saint Laurent, has been leading the way in sustainable strategies for more than a decade, placing sustainability on a par with other business functions such as finance and R&D. This policy peaked in May 2015 with the release of the group's comprehensive 'Environmental Profit & Loss' statement, laying bare the environmental impact of Kering's supply chain. It was a bold move towards transparency, but in many ways an inevitable one, as Marie-Claire Daveu, Kering's chief sustainability officer explains: 'The digital era is certainly a trigger. Customers have an unprecedented level of knowledge at their fingertips and are more and more exposed to the story behind materials, behind products.'

Operating the Kering Materials Innovation Lab (MIL) since 2014, the group is introducing potentially game-changing processes such as its 'closed-loop' technology, which is capable of recycling offcuts from various stages in production. Working closely with London-based specialists Worn Again, MIL boasts developments that recapture polyester and cellulose from end-of-use cotton, and that refashion waste fibres into new raw materials with the same price and quality of virgin silk, leather or wool. 'The future is about viewing materials innovation not as a threat to the rich heritage of luxury,' says Daveu, 'but as an enabler that will ensure the industry will thrive in the long run.'

Sustainable materials have thrown off their worthy reputation, taken a step out of the shadows and begun to make an impact on mainstream brands. One area that remains shrouded in mystery, however, is biological production. Cutting-edge innovations such as synthetic biology and genetic modification



are headline grabbing, but they obscure a whole raft of biological production techniques that are less about altering nature and more about turning natural processes to our own ends.

'Biology represents the world's greatest technology,' says Eben Bayer, cofounder of Evocative, an American company that uses mycelium fungus to transform agricultural waste into plastic substitutes. 'Grown organisms self-assemble, use polymer chemistry that is water soluble and generally benign and, best of all, exhibit tremendous complexity as an inherent function.' Other designers who are harvesting natural processes to create new materials include Julia Lohmann (*Frame* 96, p. 192), who is exploring the potential for making textiles out of seaweed, and Marlene Huissoud (*Frame* 100, p. 042), who uses insect carapaces to craft interior objects.

As biological production processes become more efficient, they're presenting viable alternatives for mainstream business methods. Footwear brands Puma and Camper are two of the bigger names currently experimenting with Piñatex, a leather substitute developed by Carmen Hijosa from a traditional Filipino pineapple-leaf fibre. With the global value of the leather market estimated to reach £32 billion by 2020, and with significant issues of waste and pollution in the supply chain, discoveries like this one are suddenly being taken seriously. Outerwear brand Patagonia has also embraced plant fibres in its collaboration with materials specialists Yulex on the world's first plant-based wetsuit.

Sustainability is being taken to the heart of industry – not as a publicity stunt but as a solid business strategy. Our sensibilities have shifted in a digital age that makes us acutely aware of the impact of our supply chains and that allows us to be increasingly sparse with the objects we choose to surround ourselves with. This change in consumer demand could be what it takes to disrupt existing industrial processes and to give new finds in the realm of materials a more central role in the future of the creative industries. ✕

FIVE DIRECTIONS FOR TOMORROW'S MATERIALS

EMBRACING THE ANTHROPOCENE

In May 2011, readers of *The Economist* found 'Welcome to the Anthropocene' in the London-based weekly. Although not yet an official part of the geological vocabulary, the term – which describes the current epoch, a period in which human activity is having a strong impact on the environment – has been fully adopted by the media. Not wanting to be left behind, designers have taken up the challenge. Scientific studies form the basis of many future-focused design projects that use the Anthropocene as a reference point and contain factual anthropogenic data. Among the results are scenarios that are not only speculative but also pertinent to existing problems.

What if man-made materials were to become part of the earth's crust and, as such, a resource for future mining operations? How would it feel to think of plastic-polluted oceans, contaminated soil and smog-filled air as 'productive'? Reverse logic, so to speak: rather than making these issues problematic, why not accept them and use them to our own advantage?

It's a topic that has preoccupied CSM Material Futures graduate Yesenia Thibault-Picazo for some time now. Commissioned by Les Abattoirs, a museum in Toulouse and the organizer of the Anthropocene Monument exhibition, she made an installation that included five participative devices featuring five mini ↳

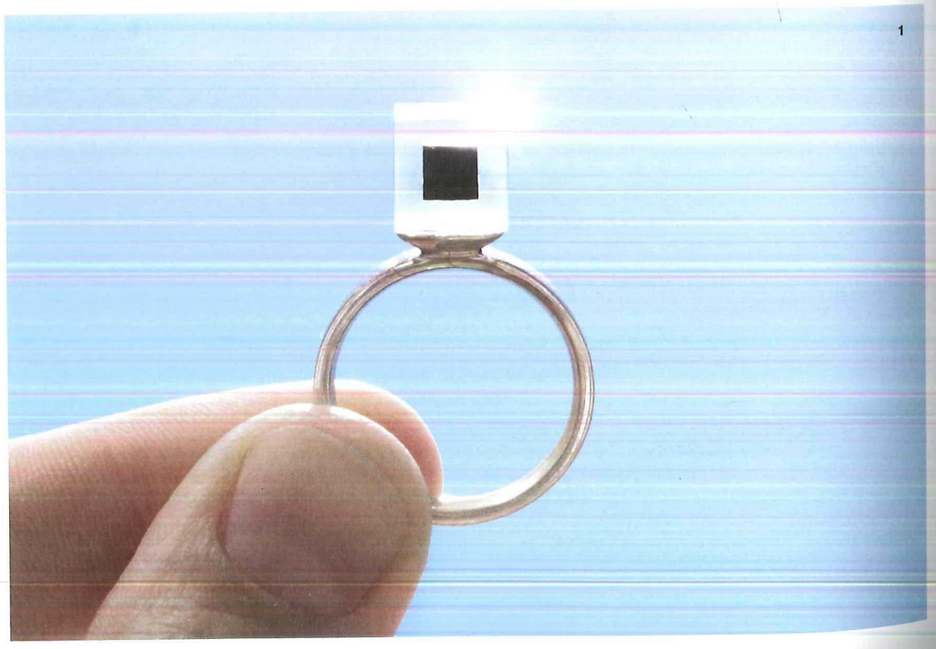


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Photo courtesy of Studio Roosegaarde

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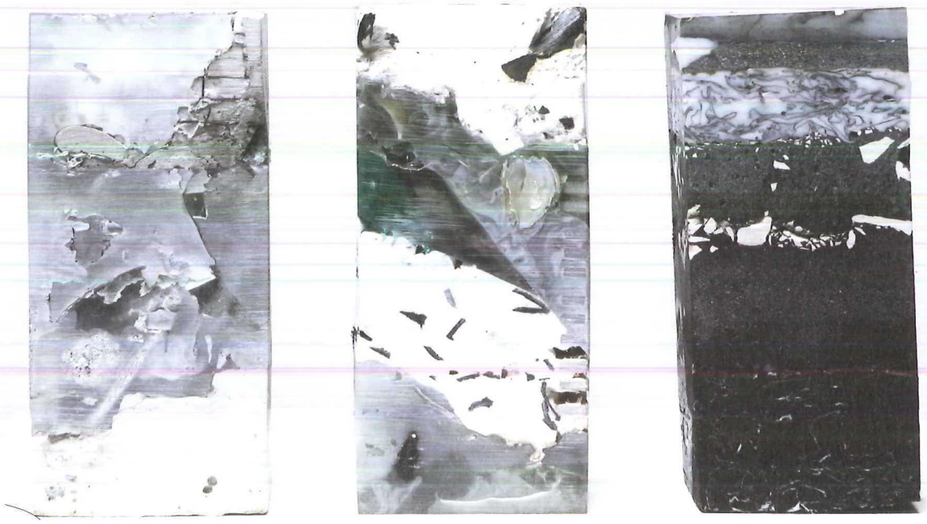
① Carbon particles collected by Studio Roosegaarde's Smog Free Tower can be compressed to form 'diamonds' for use in pieces of jewellery.

② Envisioning a future that includes the mining of newly made 'rocks resulting from human activity', Yesenia Thibault-Picazo considers the potential of tomorrow's raw materials.

③ Micro Urban Mining is Jorien Wiltenburg's proposal for harvesting valuable metals found in e-waste.

FRAME Jorien Wiltenburg demonstrates how to mine electronic waste in the *Frame* app

What if man-made materials were to become part of the earth's crust and, as such, a resource for future mining operations?



r of Wiltenburg's projects, New y, questions our perception of n the Anthropocene: the name hemist Paul Crutzen gave to sent geological epoch. Her ctions and polyester-resin tiles, nated with plastic bags and , simulate the effects of human ce on the earth's crust.

↰ oceans: a representation of the geological process of sedimentation. Thibault-Picazo suggests looking at 'plastics as part of ocean sediments' that appear to be forming 'a synthetic crust'. In her eyes, 'the threshold between the man-made and the natural is fading'.

In Rotterdam, Jorien Wiltenburg developed Micro Urban Mining, a project that promotes the extraction of metals (including aluminium and copper) from electronic waste – a major cause of 21st-century air and water pollution – for the purpose of reuse.

Studio Roosegaarde, a more influential name in Dutch design, also sees potential in the transformation of pollution-generating activities into projects of significant benefit to mankind. The latest addition to Daan Roosegaarde's Smog Free Project is a tower designed to suction particulates out of the air. 'By charging the Smog Free Tower with a small positive current, an electrode will send positive ions into the air. These ions will attach themselves to fine dust particles. A negatively charged surface – the counter electrode – will then draw the positive ions in, together with the particles.' The carbon-based particles that the tower collects during this process can be compressed into 'diamonds' for use in pieces of jewellery, such as rings and cufflinks. From valueless to valuable.

As Thibault-Picazo expresses rather cryptically: 'We celebrate the era in which Anthropos has become co-creator of a post-nature world.' And with brands like G-Star and famous personalities like Pharrell Williams working together as ambassadors for a cleaner environment – they recently launched a third denim collection made from recycled ocean plastic – there's a good chance that the ideas discussed here will thrive. — FK

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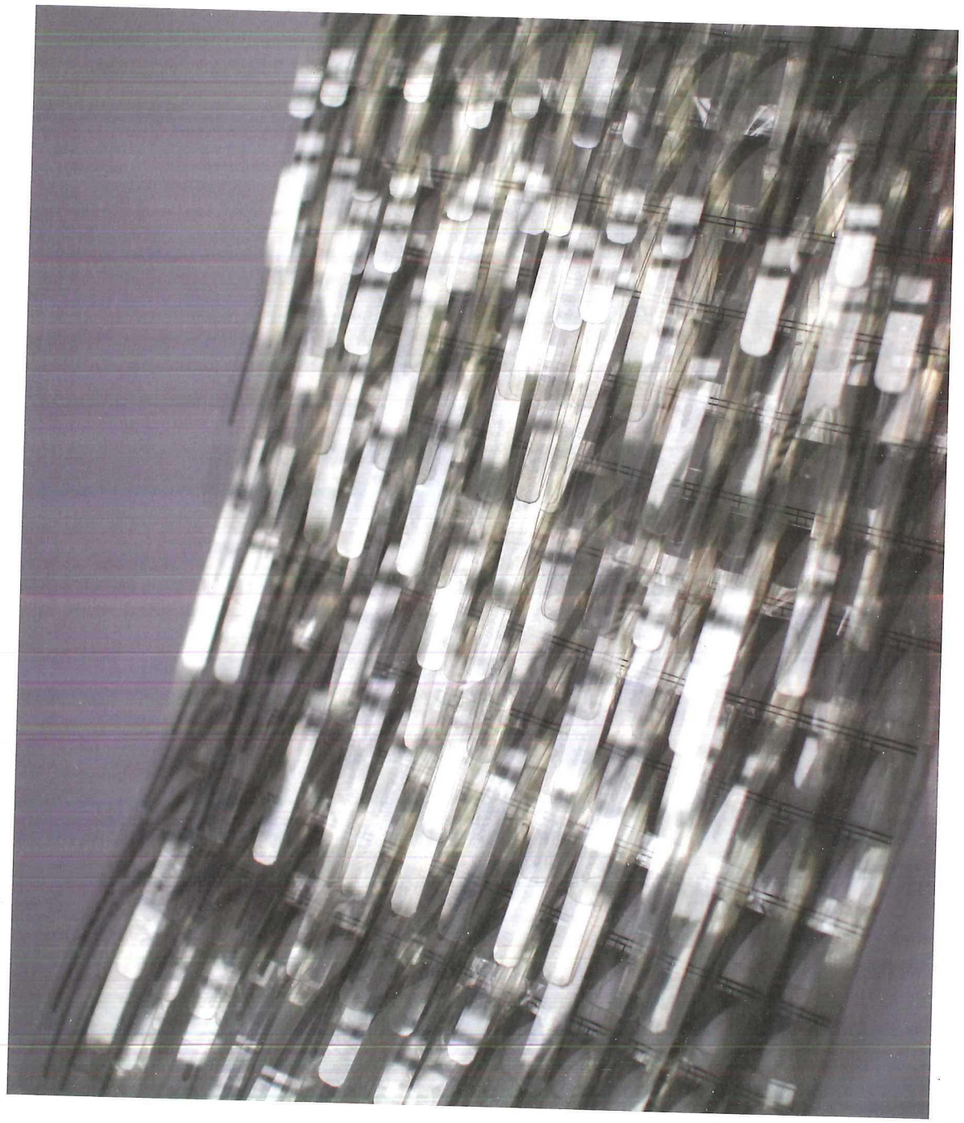
STIMULI SENSITIVE

'What I find fascinating about textiles is their structure, which is the same as that of touchscreens.' Those words were uttered by Project Jacquard founder Ivan Poupyrev, whose team has managed to spin conductive yarns that can be woven into touch- and gesture-interactive textiles on standard industrial looms. Yarns connected to circuits no bigger than a button allow the fabric to pass data wirelessly to mobile phones or other devices and, in so doing, to control functions or link users to online services and apps. Beyond textiles, however, any responsive materials that can transmit data through physical surfaces will be key to the development of media and data-infused intelligent space. These materials may be in their infancy, but as projects like Jacquard demonstrate, big changes are afoot.

This spring, BMW and students at the University of Art and Design Offenbach (*Frame* 105, p. 024) presented a fabric imbued with magnetic properties and a scalelike skin that allows drivers to adapt the aerodynamics and control signalling of their cars.

In Bath, England, Camilla Hempleman recently created the °C Thermo Color Map, a temperature- and moisture-activated Tyvek street map printed with thermochromic inks and 'activated' by specific ambient temperatures, which cause layers of hand-illustrated, colour-coded destinations to appear or to be emphasized, indicating which sites are best visited under prevailing meteorological conditions. When it rains, buildings like museums materialize in navy for wet-day sightseeing. On warm ↳

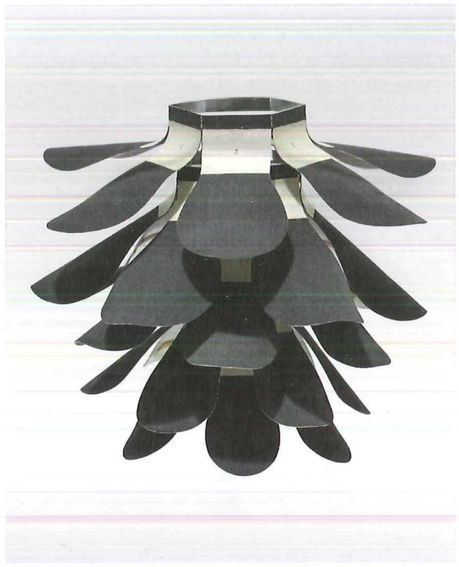


Moya, a flexible low-cost building material developed by Charlotte Slingsby, is composed of thin sheets of polyvinylidene fluoride reinforced with bendable, plastic-encased filaments that react to pressure – such as wind – to generate a charge and harvest energy.

↳ days, water destinations surface in pink, while pale-blue spots prompted by a chill in the air might include pubs that serve hot buttered rum.

Water Reaction, a project by Royal College of Art student Chao Chen, is a laminate based on his study of the pine cone, which opens when dry and closes when wet. He wants to design building materials that are capable of shifting shape according to climate. Chen suggests applications for the film he's made, which is layered with humidity-responsive lime veneer: two examples are laminated roof tiles that admit light in good weather but form a stack or an umbrella overhead in inclement conditions, and flat architectural cladding that curls into petal patterns when exposed to moisture. Chen is working on commercializing his ideas.

In the case of Project Jacquard, for the moment it's mainly fashion brands like jeans giant Levi's that are sewing the technology into their products. But with money-bags megabrand Google as its sponsor, Jacquard can extend its applications to include virtually any textile – from automotive upholstery fabrics to sofas and curtains – making soft surfaces the new devices. — **SM**



n envisions his humidity e surfaces – based on a pine action to water – as an exterior ural material that adapts to conditions.

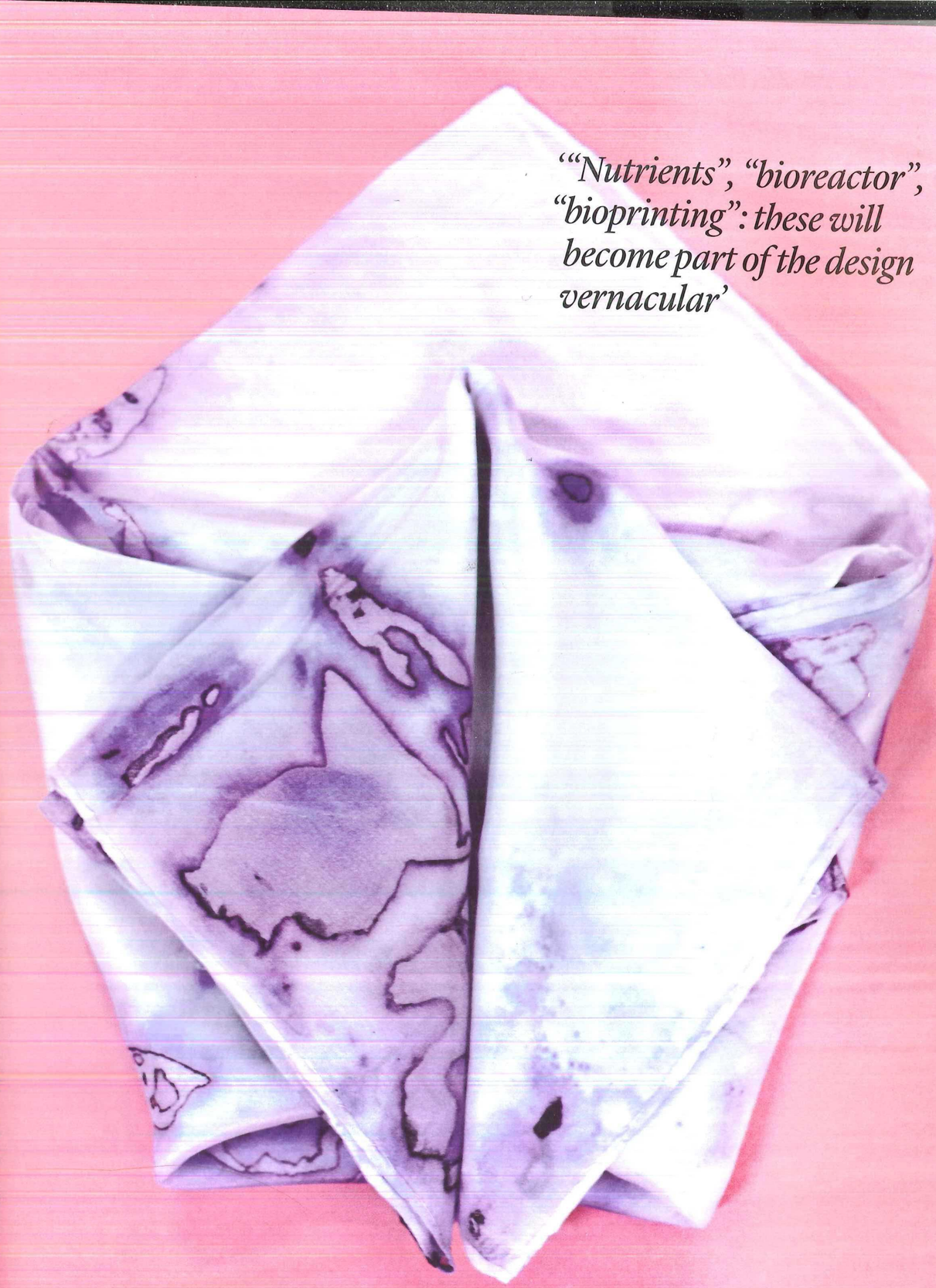
SEEDS OF CHANGE

'While the technology is relatively new, there's no question that this is *the* way we'll be fabricating in the future.' These are the words of Suzanne Lee, founder and curator of Biofabricate, the first summit on grown materials, and creative director of Modern Meadow, the only company in the world to currently grow real leather. 'Relatively new' means the last five years. That's when companies growing materials for consumer applications started to appear, although 'most people won't yet recognize that there is a new generation of materials and manufacturing processes emerging that are founded on living organisms,' says Lee. 'Interestingly, many of the early biomaterial companies have been founded not by scientists but by architects, designers, engineers and even artists.'

What sparked the grown-materials movement and *why* people like Lee believe in its longevity are intimately linked. While various factors are involved, the common thread is sustainability. 'There's a strong pull from brands and manufacturers trying to find solutions within our increasingly strained resources, such as finding alternatives for petrochemical-based materials.' Alki has just launched Kuskoa Bi, the first commercially available chair to be manufactured in bioplastic, for example, while Bolt Threads is growing spider silk for clothing, which had never before been commercially possible. Lee believes that necessity often leads to new innovations. 'If you can grow a fibre with the performance characteristics you need and in the colour you want, why would you return to a more industrially and chemically intensive method? There's also an increasing pull from more conscious consumers who are concerned about what things are made of, how they're made and by whom – and the impact of those processes.'

Serious sustainability is what motivates Eric Klarenbeek. He's working on an ongoing series of projects generated with mycelium with an eye to negative carbon footprints. Klarenbeek believes that 'in the near future we'll probably print and grow cities'. It's not hard to imagine with examples like Hy-Fi, The Living's MoMA PS1 pavilion, built of bricks made from cornstalk waste and living mushrooms. The project was the world's first large-scale outdoor construction to use the material. Pedro Gadanho, MoMA's architecture curator at the time, noted that 'this material could become a staple for building in places where resources are very limited'. ↳

'"Nutrients", "bioreactor", "bioprinting": these will become part of the design vernacular'



Design researcher Natsai Audrey grows bacterial prints on silk scarves for her Fold series.

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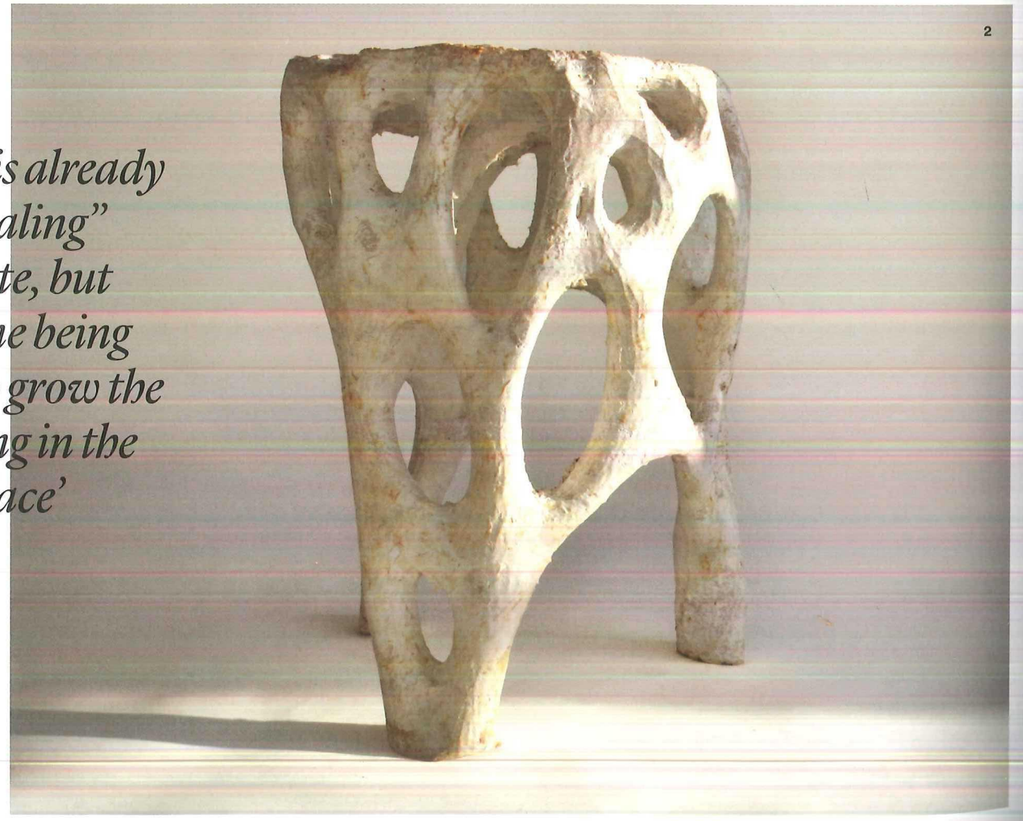

'There is already "self-healing" concrete, but imagine being able to grow the building in the first place'

① Terreform ONE's prototypes for sculptural furniture incorporate mycoform, a product grown from ordinary biological matter and added to compacted forms of inert waste. At the end of the product's lifecycle, it can be safely returned to the natural environment.

② Veiled Lady stool is part of Mycelium Project 2.0 – Eric Klarenbeek's next generation of mycelium-grown objects. The product is completely compostable.

③ The Living manufactured 10,000 compostable bricks for the Hy-Fi MoMA PS1 pavilion. After the structure's three-month lifespan, the bricks were disassembled and composted, and the resulting soil was given to local community gardens.

↰ While mushrooms seem to be popular among the material-grower community, fungi are just one of various organisms being employed. Bacteria, yeast, algae and mammalian cells are others. 'These are amazing organisms that can be optimized to produce tuneable materials where you can dial in the functionality you want them to have,' says Lee. 'For me, the most exciting part is the vision of direct manufacture. Imagine being able to grow a finished product, like a shoe. It will be a one-step process from fibre to form with no need for seaming. Or think of product scaffolding where you see a structure and grow it into a form. There is already "self-healing" concrete with bacteria embedded to grow and fill cracks, but imagine being able to grow the building in the first place. I'm much more excited by the prospect of bioprinting with living materials than 3D printing with plastics. We'll start using new vocabulary in relation to design and manufacture. "Nutrients", "bioreactor", "bioprinting": these will become part of the design vernacular along with new tools that allow designers to experiment with biology. Design education seriously has some catching up to do.' — TI

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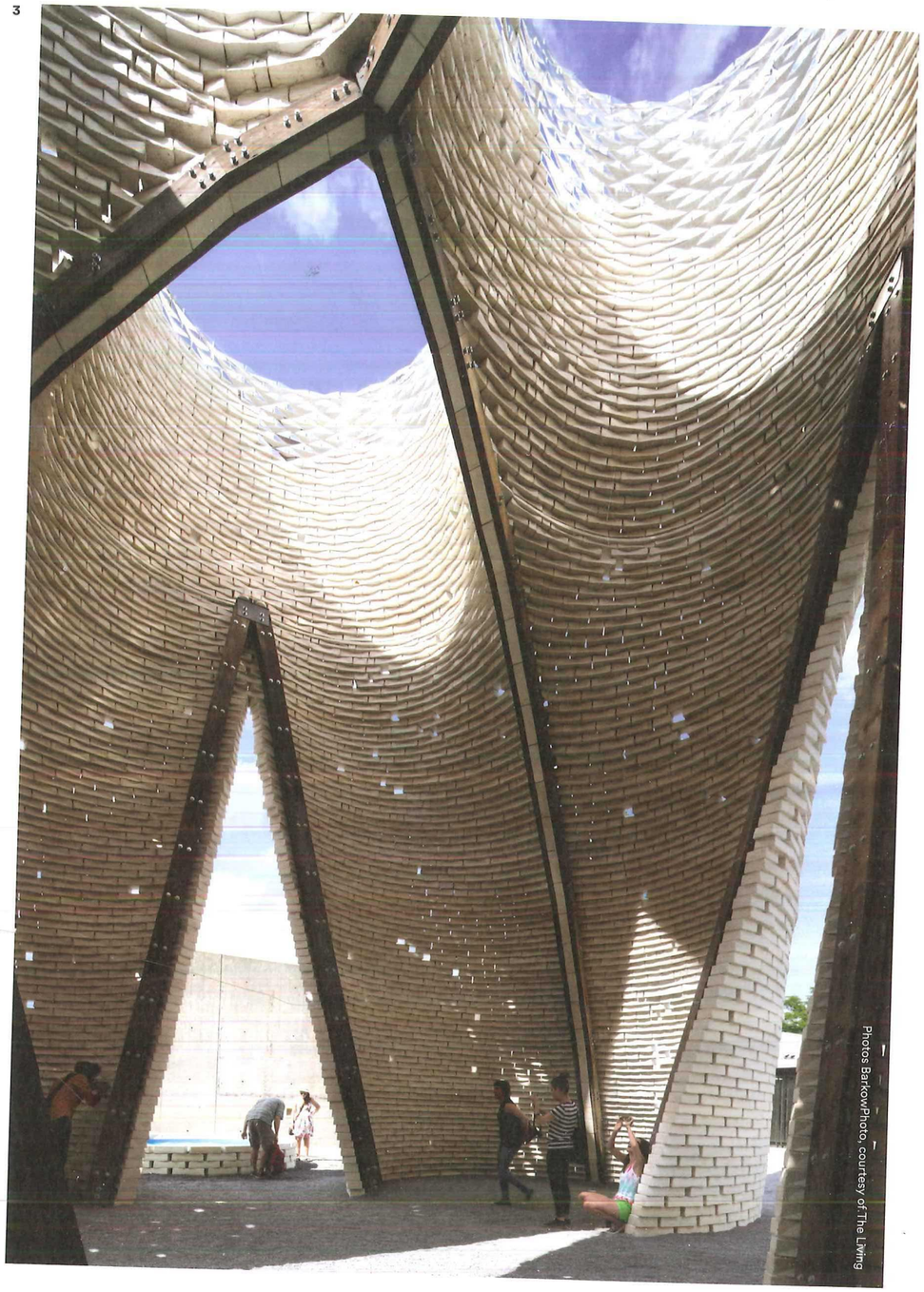


Photos BarkowPhoto, courtesy of The Living

MAKE MATTER MATCH

Photo courtesy of BASF

norrow's materials need to form on multiple levels says Alex risberger of BASF's Designfabrik

You've been working with materials for a while now. What recent developments have the most potential? ALEX HORISBERGER: Smart materials have great potential. Generally speaking, expectations for today's materials are rising rapidly. They need to perform on multiple levels. Being lightweight or rigid isn't enough any more. Materials that adapt autonomously to a changing environment are in high demand. Some become softer under pressure or conductive under certain conditions – interesting new properties.

How do you envision the future of materials? We tend to separate 'natural' materials – such as wood, cotton and metal – from 'artificial' materials, like plastics, synthetics and laminates. What happens when you give artificial materials a distinctive identity by adding a unique look, a texture or a special touch? Can we create a new mind-set for these materials? I love the aesthetics of carbon fibre laminates. The imperfect look is a refreshing new direction in a globalized world of uniform products.

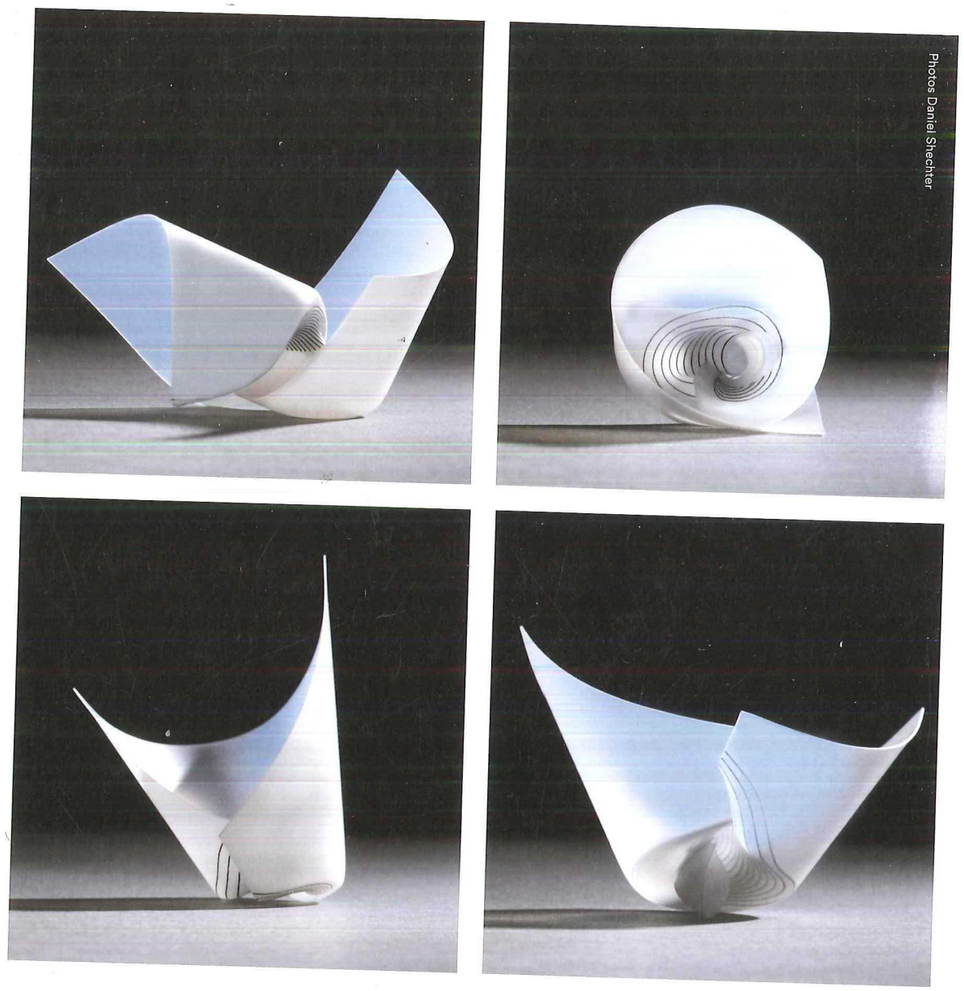
Clients come to Designfabrik from a wide range of disciplines. What industries are leading the way in terms of materials? I tend to say the automotive industry – although the fashion and furniture sectors have many interesting concepts to offer as well. We are at the edge of a great evolution in human transport. Everything that relates to autonomous driving is changing the industry in so many ways, but autonomous driving requires drastic changes in the use of materials. If being in a vehicle isn't all about driving, but more about living, it needs different 'furniture'. And if you don't *own* a car but share it, requirements for the interior change in that case as well.

Has the notion of materiality changed?
I am happy to confirm that the general perception of materials used by designers has changed. In the past, I noticed many projects that progressed to the very last stage before the designer chose a material. We work in the opposite direction. For us, material is a source of inspiration. We want every design to harmonize with the characteristics of the material. That's why BASF created the Designfabrik: to provide designers with solutions and support in their quest to think beyond pure aesthetics or performance. We help them to connect colour, surface and technical feasibility.

If you could come up with a brand-new material, what would it be? Can you describe its properties?
It would definitely not be one single material. Imagine a tree: you can sit on its branches and be sheltered from rain and sunshine while it cleans the air. It's simply beautiful and lasts longer than a human lifetime. But: it's not a single material; it's an organism. Now imagine a car covered with something that self-repairs scratches, doesn't heat up in the sun and glows in the dark – this is not a single material but something resembling an organism. It's what I would call the Holy Grail of materials. — **FK**

Building on the materials portfolio of German chemical company BASF, Designfabrik supports industrial designers and manufacturers in their search for the best materials for their projects
designfabrik.basf.de

INSTRUCT TO CONSTRUCT



Photos Daniel Shechter

Traces, a series of self-folding structures by Dana Zelig, explores the concept of programming everyday materials.

4

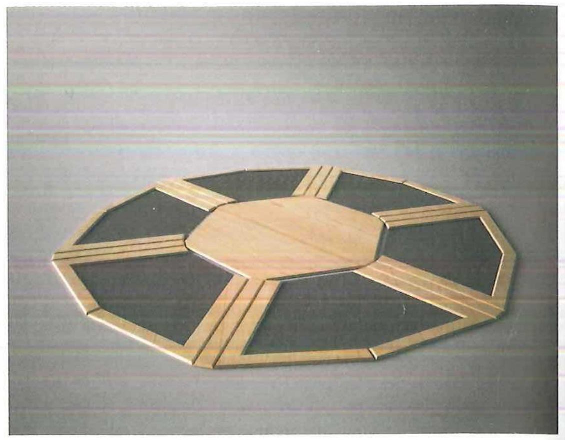
Making robots without the robotics? Recent advances in materials science and engineering have yielded a range of materials – including electroactive, thermo- and strain-responsive polymers and alloys – that can be assigned to perform repeatable tasks. But 'programmable materials' aren't coded with a series of 0s and 1s; instead, researchers are making automorphic objects by printing, injecting, laminating and prestressing proclivities (to crease, curl, expand or self-assemble, say) into the material itself. The team at MIT's Self-Assembly Lab has dubbed it '4D printing'. Anything from carbon fibre and polymers to ordinary wood and textiles can be activated by exposure to catalysts like heat, infrared light, humidity or even the very act of being unpacked.

This description may call to mind memory wire, the prestressed polystyrene toy Shrinky Dinks, or Issey Miyake's Pleats Please collection: clothes that expand from 2D geometric shapes to become soft 3D structures. But today we have sneakers that lace themselves, wall lights printed with conductive ink onto sheets of paper, and panels that shift and morph to make race cars racier. Researchers at MIT and the University of Technology Munich have even made a miniature origami robot that can fold, walk, swim and, Mission Impossible-like, destroy itself through degradation. But programmable materials could also become the basis for self-assembling furniture (already being pioneered by Ikea) or interior-architecture elements – either prefabricated with bespoke thicknesses and grain directions or printed with sensor-like 'skeletons' – that ship flat-packed to a building site and pop into form when uncrated.

The ambassador of materials programming may be the humble but lyrical Traces, a dozen dancing polymer sheets designed by Tel Aviv-based Bezalel Academy graduate Dana Zelig with Dr Ido Bachelet. Zelig and Bachelet inkjet-printed dark patterns on sheer polymer sheets, which after exposure to infrared photons and therefore targeted heating, flex and arc into sculptural forms. ↳

…tion between MIT's Self …ab and Wood-Skin S.r.l., …ble Table makes use of an …prestressed textile that …o actively transform itself.

↰ 'Adaptation to environmental changes is a hallmark property of living organisms, but its introduction into objects and architecture is still primitive,' Zelig points out. 'Responsive environments and objects remain a collage of hardware components that activate their materials and structures.' Researchers and designers, however, are rapidly expanding the range of everyday materials and energy sources used to activate objects, lowering their cost and broadening their application. It won't be long now before programmable materials are scaled up for use in adaptive architecture. No Turing test required. For anyone with a robot or android phobia, this should come as a welcome relief. — SM



It won't be long now before programmable materials are scaled up for use in adaptive architecture

SECOND LIFE

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As of late 2015, the EU is introducing an ambitious new circular-economy strategy aimed at positioning waste as a valuable resource. In Europe, at least, incentives for reusing, repairing, refurbishing and recycling look set to increase exponentially, and some innovative initiatives that indicate how the strategy might take shape are already under way.

For his new home and studio in Utrecht, the Netherlands, Rolf Bruggink added a sculptural interior scavenged from a neighbouring 1950s temporary office building. 'I wanted to use *every* part of the office building,' says Bruggink, who worked with fellow designer Niek Wagemans on House of Rolf. Bruggink is aware of the obvious environmental benefits of reusing materials, but they're not his main motivation. 'For me, the conceptual aspect of transformation is important, too. When you reuse materials, you create completely different things than if you had used new ones. The results are richer, more unique and specific, with a history attached to them.'

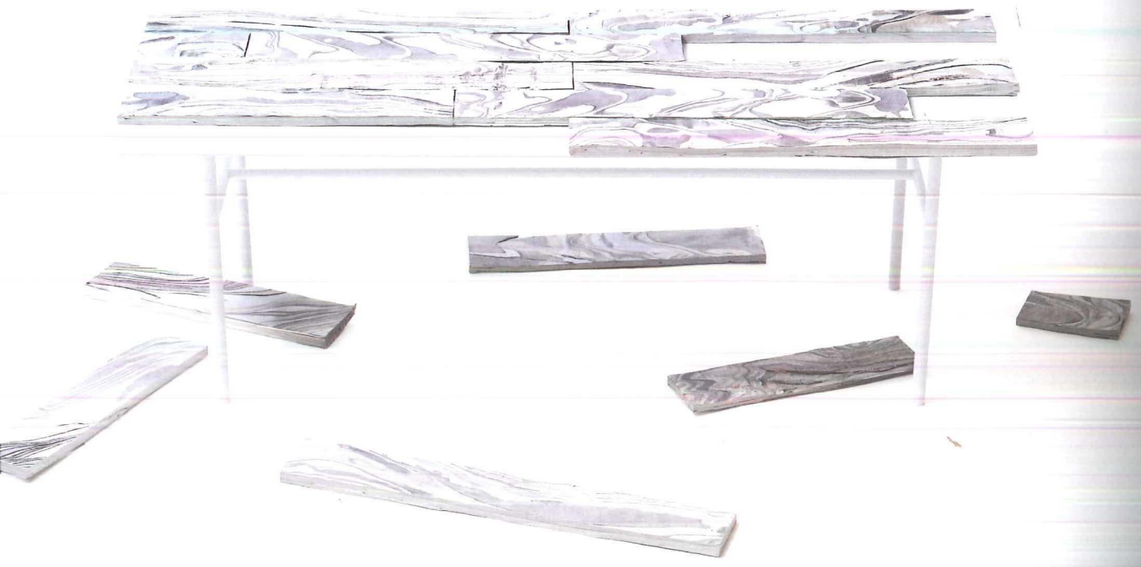
Deconstruction rather than demolition – as in Bruggink's reuse of a whole building – may currently be an artisanal approach, but in the future it will move mainstream and be conducted on an industrial scale as we transition to a circular economy. Businesses will discover – as many designers and artists already have – that reuse not only saves energy and resources and reduces pollution, but also adds new levels of meaning and value in the eyes of consumers. Conjuring your own materials via reuse is already a cottage industry – an established part of the 'making' trend in design – and will ultimately become an important aspect of mass manufacturing, too. This autumn, for example, H&M launched a recycled denim line called Close the Loop, made from the clothes it has been collecting from customers since 2013.

Waste food, an abundant yet often invisible commodity, offers huge potential as a resource. Isaac Monté, for instance, 'decellularizes' supermarket meat that's past its sell-by date and dries it to create a material reminiscent of marble (*Frame* 104, p. 232), calling the final product 'a reaction against waste'. Fruitleather Rotterdam gleans discarded fruit and vegetables from the city's outdoor markets, cooking, mashing and drying them to produce a hide-like material. The process draws parallels with two new and versatile recycled materials already being industrially manufactured from waste cellulose and water: Zeoform, a plastic substitute, and Ecor, an alternative for MDF. Although the current low oil price ensures a competitive price for plastic, the growing scarcity of carbon-based resources, not to mention ↳

'It was important to use everything in a totally different way,' says Rolf Bruggink of Studio Rolf.fr who, in collaboration with Niek Wagemans, reused an entire office building in the construction of his home and studio. 'The many old radiators became a structural element – they are holding up the first floor.'

Photo Will Yates-Johnson

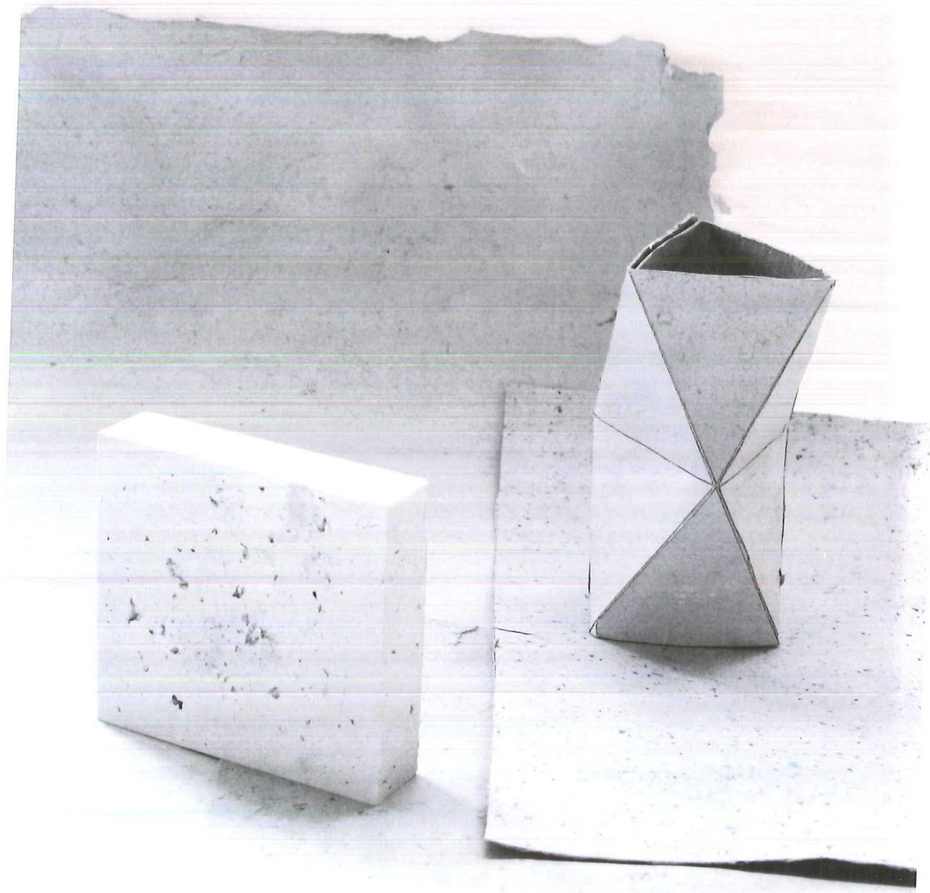
Reuse not only saves energy and resources, but also adds new levels of meaning and value



① With Polyspolia, Will Yates-Johnson proposes a new manufacturing model that allows an object to be broken up and remade endlessly.

② In Alcantara-Wood, Nendo uses layers of artificial suede to 'make' timber. By layering various colours of fabric before rolling them out and cutting them on the bias, Nendo mimics the grain of natural wood.

③ DAE graduate Sam Linders researched the possibilities of transforming fibre shavings from chrome-tanned leather (wet blue), which are currently going to waste, into new materials. Some share characteristics with paper, while others resemble marble.



the 'leave it in the ground' movement, will eventually tip the scales in favour of these and other newly developed natural materials.

Often a design is required not only for the production process but also for the collection process of waste earmarked for reuse. Business and social innovation on a huge scale will help drive the closed material loops of the circular economy. Illustrating the point is Amsterdam community initiative Wasted, which encourages locals to recycle their own plastic. In addition to benefiting from a rewards system, those who sign up learn how to make colourful blocks that can be used to build items for the community, like park benches and market stalls.

For the bird-feeder line he produces for A Short Walk – the reused materials design company he founded after leaving Dyson – Dan Dicker says the company has had to start its own UK-wide collection scheme to obtain redundant plant pots. Garden centres are where he sells the bird feeders and where he gathers the raw materials for his project. 'From a demand perspective,' he says, 'the trend will always move towards materials with a good closed-loop story that consumers can relate to.' — JS