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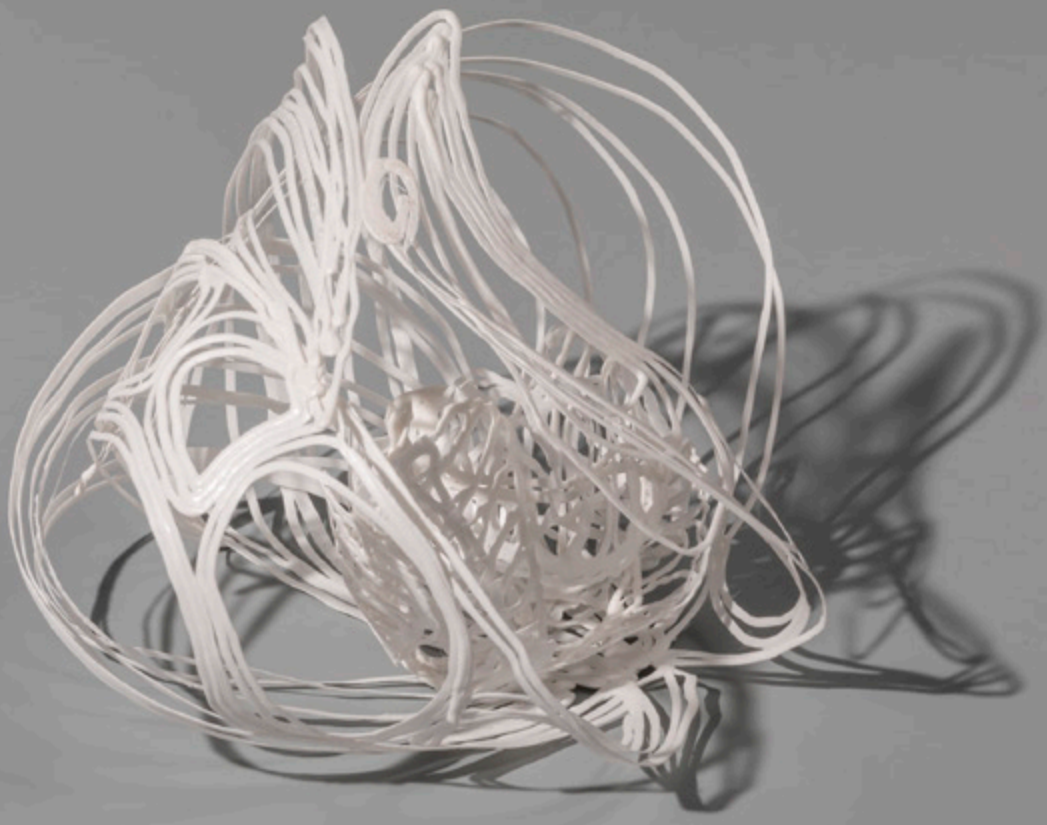

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Editorial

In this issue, Heidi Fischer reflects on a returning to place as an antidote to our restless society and an opportunity to witness the sublime in the ordinary, as she accompanies photographer Richard Laugharn on one of his regular pilgrimages into the "Black Heart" of the Sonoran Desert.

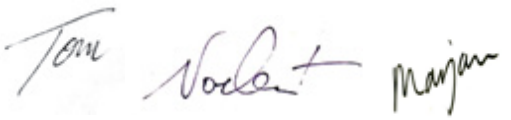
Dry conditions shape the form and life there, and in our next article, engineers Brook Kennedy, Jonathan Boreyko and Weiwei Shi of Virginia Tech, recount their own journey of discovery in designing and patenting their innovative Water Harp, a fog capture device that increases the yield of water collection over traditional devices.

Artist Fraenzi Neuhaus explores tension and shape in making synthetic interpretations of complex natural forms. Placed in urban public spaces, these forms prompt a much-needed reflection on natural space and perhaps their own sense of place.

Editor Norbert Hoeller and well-known biomimic Julian Vincent continue their quest to grow community and inculcate biom* (all disciplines that look to nature for solutions) within the practice of designers. They travel to the Netherlands for workshops in Delft at the Design Society annual gathering, and apply a rational approach to aligning the needs and values of designers with the practice of bio-inspired design.

Finally, we tally up the results of our ongoing Reader Survey - who's looking, and who's liking which of our articles. We depend on your feedback to make this the best offering we can, so keep your votes and your comments coming.

For now, Happy Reading! ×



Tom McKeag, Norbert Hoeller and Marjan Eggermont

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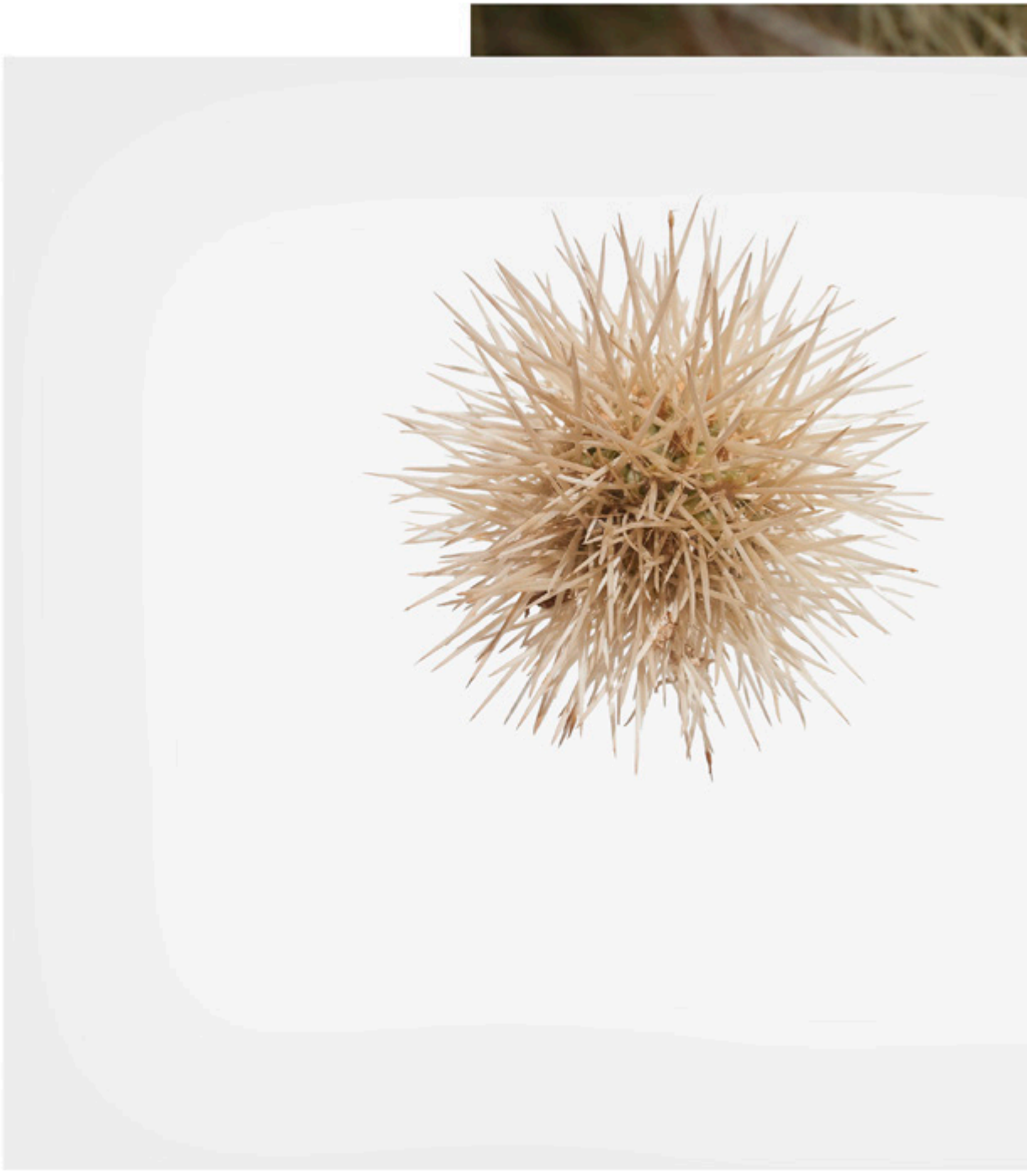


The Red Cone Cholla (OB04 140227)
Richard Laugharn

The Science of Seeing

Been There, Done That, Wanna Do It Again

Adelheid Fischer | Photographs by Richard Laugharn

Been There, Done That, Wanna Do It Again

Adelheid Fischer | Photographs by Richard Laugharn

In this convulsive age of uprooted populations and extensive diasporas, holding onto places—and sensing fully the goodness contained therein—has become increasingly difficult, and in years to come, I expect, it may everywhere be regarded as a privilege and a gift.

Keith Basso

How many humans have had the patience to know even one saguaro well?

Gary Paul Nabhan

"Watch for rattlesnakes." Richard Laugharn tosses these words of caution over his left shoulder as I trail him into the Sonoran Desert just north of the Mexican border near the tiny mining town of Ajo, Arizona. We pause mid-step as he points to our destination: a stately cactus, known to him as the Black Mountain Organ Pipe, growing at the base of an isolated rise of jumbled rocks a quarter-mile distant. Laugharn issues the rattlesnake warning more out of habit than real concern. In the chill of this winter morning, it is unlikely that we will encounter any wide-roaming vipers. We have traveled to the desert at the tail end of a February storm so bitter and wet that frost penetrated even the lower elevations, and snow blanketed the peaks around us. With only the hint of warmth from a pale halo of sun, my guess is that any reptile in its right mind would be choosing the comforts of a den over a stroll around the premises.

Laugharn is no stranger to the borderlands desert. At least once a month for the past two decades, he has left his fine-art framing business in Tempe and pointed a truck loaded with cameras and camping gear in the general direction of Mexico. Although he has undertaken his share of solitary trips, more often than not Laugharn is in the company of other travelers. They include fellow photographers, scientists, writers and historians, many of whom are part of an informal, but well-established, network of desert rats united by their passion for the human and natural history of this drylands region. Indeed, in a few hours we'll meet up with a small party of archeologists and biologists. Together we'll caravan to a campsite in Mexico's Pinacate Biosphere Reserve, a place that writer William Hartmann calls the "black heart of the Sonoran Desert" for its massive landforms the color of dark chocolate. Thick flows of ancient lava, measuring 25 by 35 miles, have created a landscape of cracked-rock outcrops and steep-sided cinder-cones so distinctive that they are clearly visible in photos from outer space. Running alongside the western edge of this volcanic zone is a monumental dune field whose ancient sediments were excavated by the Colorado River

The Black Mountain Organ Pipe (ST01 181018)
Richard Laugharn

Been There, Done That, Wanna Do It Again
Adelheid Fischer | Photographs by Richard Laugharn

from the Grand Canyon some 300 miles to the north. From trough to peak, its largest swells are as tall as the Statue of Liberty. Pinacate has a reputation for being a center of gravity that sucks desert lovers into its orbit where they can circle for a lifetime. Many of them have become so devoted that their families scatter their ashes into the winds there. Laugharn too has developed deep ties. He named his dog, Kino, after the Jesuit missionary and explorer Eusebio Francisco Kino who traversed its parched expanses in the 17th century. Laugharn's son, Hayden, bears the name of the renowned 20th-century archeologist Julian Hayden, who spent a lifetime in his legendary International Travelall studying the traces of the prehistoric people there.

But while many photographers have focused a camera lens on the Sonoran Desert's larger-than-life geological features, Laugharn has trained his aperture of interest on the near ground, homing in on living things that are far more ordinary and closer at hand—great spears of agave leaves, the lone sentinel of a saguaro cactus, creosote galls, the blossoms of ironwood trees, the stems of ocotillos, sometimes bare, other times fully leafed out like stitchery on the page. Before the rendezvous with our Pinacate companions, Laugharn planned this brief detour near Ajo to revisit one of them—the Black Mountain Organ Pipe. He first documented the cactus in 2001. Since then he has returned some 72 times in conditions ranging from riotous spring wildflower blooms to July scorchers in which temperatures approached 120 degrees. The cactus is only one among one hundred plants that Laugharn has diligently (some say obsessively) documented over the years. Although he has recorded their GPS coordinates in his journal, he rarely refers to his notes. He knows the plants' locations by heart.

Laugharn, whose name rhymes with "yarn," is aptly named. As we walk, the stories he has collected about this place begin to unspool. Despite its ruggedness, which can turn deadly on a dime, this landscape has a long history of human occupation, and Laugharn has been a devoted student of its fantastical twists and turns.

From time to time, he interrupts his storytelling to marvel at the white-capped peaks on the mountaintops. Snow in the desert here is a novelty, and he can hardly contain his delight. These pauses give me time to take a good look around. The landscape around Ajo is among the most beautiful in the Sonoran Desert—100,000 square miles of arid geography that spills across portions of Mexico, California and Arizona. This part of the desert is located

in basin-and-range country—a rhythm of isolated mountain ranges that rise and fall like melodies along a topographical bass line of broad flat valleys. Back in 1969, the spot on which we are standing was part of national park proposal of seven million acres that then-Secretary of the Interior Stewart Udall pitched to outgoing President Lyndon Johnson. In the final hours of his presidency, Johnson inexplicably failed to include the borderlands as part of a package of public lands proclamations. Had Johnson not reneged, the set-aside acres might have served as the kernel for an even larger binational park with greater guarantees of protection for the desert's waters, plants and animals and archeological treasures.

Still, precincts of beauty, like the one we are traversing, remain. Those who have never set eyes on the Sonoran Desert conjure it as little more than great sifts of Sahara-like sand. Yet nothing could be further from the truth. Of the four major deserts in the American West, the Sonoran Desert is by far the most biologically diverse, hosting more than 2,000 species of plants alone throughout its reaches. Though vegetation can mob the more well-watered banks of cienegas and arroyos, the desert generally does not encourage crowding. Indeed, newcomers often remark upon

The Black Mountain Organ Pipe (ST01 171126)
Richard Laugharn

The Black Gap Wolfberry (LF01 050820)
Richard Laugharn

Been There, Done That, Wanna Do It Again
Adelheid Fischer | Photographs by Richard Laugharn

its resemblance to a Zen garden. Islands of small trees, mostly ironwood and palo verde, anchor the spare design. Ocotillo and creosote bush launch crimped wands into the gaps. Now and again great columns of saguaro cactus skewer the tree tops. They are joined by the bulbous thumbs of barrel cactus and corrugated flutes of organ pipe whose elaborate stem clusters resemble the pipes of a church organ. In a place that gets an average of less than eight inches of precipitation annually, the plants give each other wide berth. The capaciousness appears formal, intentional. The wide margins around things create a kind of stillness, in which plants can break the silence one at a time and begin to speak.

The Black Mountain Organ Pipe is one of them. Like the rest of Laugharn's subjects, it does not stand out as an especially perfect specimen or odd in some photogenic kind of way. No historic treaties have been signed or famous generals fallen at its feet. It has not called to Laugharn in some magical, mystical way. Nor is there the kind of socio-political double-text that underlies so much other contemporary borderlands photography in this time of humanitarian, political and environmental crises. Laugharn's protocol is bedevilingly straightforward: his subjects are largely chosen at random and invited to step out from the anonymity of their ordinariness into the camera's frame. By revisiting them time and again, his self-appointed task is to discover what is worthwhile and interesting about what they have to say.

The Signal Mountain Ocotillo (FS01 140717)
Richard Laugharn

It's an artistic process that can cause some of his fellow desert photographers to foam at the mouth and writhe with boredom, he chuckles, as he pulls out a camera and begins slowly circling the plant. "The way I work is different from most other photographers," he points out. "They encounter something very briefly. They don't live *with* it for any period of time."

I first learned about Laugharn's unusual artistic practice from a mutual friend, a fellow photographer who admired both his process and his work. I was intrigued. What would it mean to devote yourself to ordinary things for years, even decades, to eschew the spectacular, the once-in-a-life-time in favor of the everyday, to return to it, to look again, ponder, look some more, like waves revisiting the same patch of shore?

It struck me as a contrarian, maybe even a little cantankerous, approach to making art, to forging a connection to place, to living a life. Laugharn's process seemed to swim against the trending tide of our inattentional culture which, instead of cultivating a faithfulness to the water's edge, has opted for a one-way race out into a vast ocean of new adventures, a place of perpetual motion that mostly washes up on a horizon of receding promise.

Perhaps more than anything, it pushed back against the impatience and jitziness that infuse contemporary life. According to the U.S. Census Bureau, for example, the average American will move 11.4 times over his or her lifetime. And just as there are always new places to go, there are always new things to see, new people to meet. Take the speed with which people click through the digital emporiums of romantic love known as online dating. Research shows that women take an average of 84 seconds to make a judgment about the suitability of an online profile while men shave that time down to an average of 58 seconds. This pace seems downright glacial when compared to, say, the request that I overheard recently while strolling through a small art gallery in Tucson, Arizona. A mother next to me asked her young daughter to select her favorite painting and then spend 30 seconds looking at it. Could she have been familiar with the research showing that visitors to museums spend an average of only fifteen to thirty seconds at an artwork before moving on to the next? It was a life lesson, as if she were helping her daughter to awaken from the long slur of absent looking that results from living like perpetual tourists relentlessly craving the shock of the new and its synapse of momentary satisfaction. It was about bringing awareness to the mindless itch that drives us to notch as many countries on our belts as possible before arthritis hobbles

Been There, Done That, Wanna Do It Again
Adelheid Fischer | Photographs by Richard Laugharn

our capacity to walk a jetway, treat our relationships like a fast-paced game of musical chairs, regard the plants and animals that share our planet as little more than mute curiosities in the drive-by backdrops of our lives.

Laugharn's artistic philopatrism is a counterweight to this. The scientific term, from the Greek meaning "home-loving," refers to the faithfulness that many animals have to their home ground including some salamanders, for example, that don't venture beyond 150 feet of their burrows or some scorpion species that whittle that distance down to three feet.

But Laugharn's philopatrism wasn't necessarily a conscious choice. "I have long been drawn to the desert," he would later tell me on the road to Pinacate. "After many years, I'm still unsure how to account for this affinity."

I understood exactly what he was saying. It's the experience of having someone, some thing, some place put its dibs on you. It's the difference between choosing and being chosen by something that is doing the choosing for you, the writer David Whyte explains. It's the experience, he says, of feeling as if you have "been sought out by the world, sought out, acknowledged, named and recognized."

Laugharn's response has been to become what he calls an "ardent student of this vast desert." His shelves are filled with books that capture the stories of the Sonoran Desert from every possible angle, from fine art, natural history and geology to archeology and cultural history. His photographs, he writes, "are my contribution to this exchange of stories, the goal of which, is to bind ourselves to a place that has made a claim on our imagination."

The desert, perhaps more than any other biome, does that to people. I first set foot in the Sonoran Desert in my 40s, having spent most of my life in the forests of the Upper Midwest. The desert inexplicably felt like home, yes, but there was a connection even deeper than that: the desert felt like my destiny. I knew that I would spend the rest of my life here untangling the threads of its hold on me. Like Laugharn, I would find myself pacing familiar terrain craving the shock of the familiar.

As I watched Laugharn circle the organ pipe cactus, I thought of John Hoel, a character in the first chapter of Richard Powers' novel *The Overstory*. In it Hoel, a young farmer, buys what was a technological novelty in 1903—a Kodak No. 2 Brownie. To the puzzlement of his family, on the same day each month, he begins to photograph the chestnut tree that his immigrant father

The West Riverside Creosote (LT01 061013)
Richard Laugharn

Been There, Done That, Wanna Do It Again
Adelheid Fischer | Photographs by Richard Laugharn

brought as a sapling from Pennsylvania and planted on the family' prairie homestead in Iowa. The first year's sheaf of photos "show[s] little for his enterprise," Powers writes. "In one instant, the tree makes leaves from nothing. In the next, it offers up everything to the thickening light. Otherwise, the branches merely endure." Over the years, Hoel persists, despite the fact that he receives no end of teasing from his wife and children. Struggling to explain her husband's photographic ritual, Hoel's wife derisively states: "He's waiting for it to do something interesting."

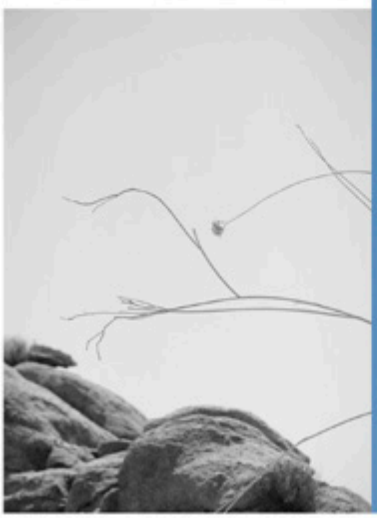
In Powers' novel, taking the time to really look at the so-called ordinary things around us is the starting block for an extraordinary adventure. "It's amazing how crazy things become," he writes, "once you start looking at them." The transplanted chestnut tree in Powers' novel that has taken root and thrived on the prairie, like the plants in Laugharn's series of photographs, are far more than merely "interesting." They are miracles, a word that comes from the Latin meaning "objects of wonder." In the desert, for example, only a minuscule fraction of the millions of seeds that germinate go on to survive a gauntlet of hungry rodents and rabbits, desiccating winds, droughts and deep freezes. In nutrient-poor soils that receive less than 8 inches of rain each year, they build great towers of fleshy stems, they sprout leaves seemingly overnight after episodic rains, they grow sturdy, woody branches, sprout thick, waxy blooms and lift up succulent fruits to the broiling sky using, as Powers points out, little more than nothing: sunlight, air and a teaspoon of minerals. Many of them are surprisingly long-lived, like ironwood trees, which can grow to be 1,500 years old, bearing witness to the passing of conquistadors and cattlemen, padres and 49ers or, as Laugharn points out, the ups and downs, the joys and disappointments of his own life.

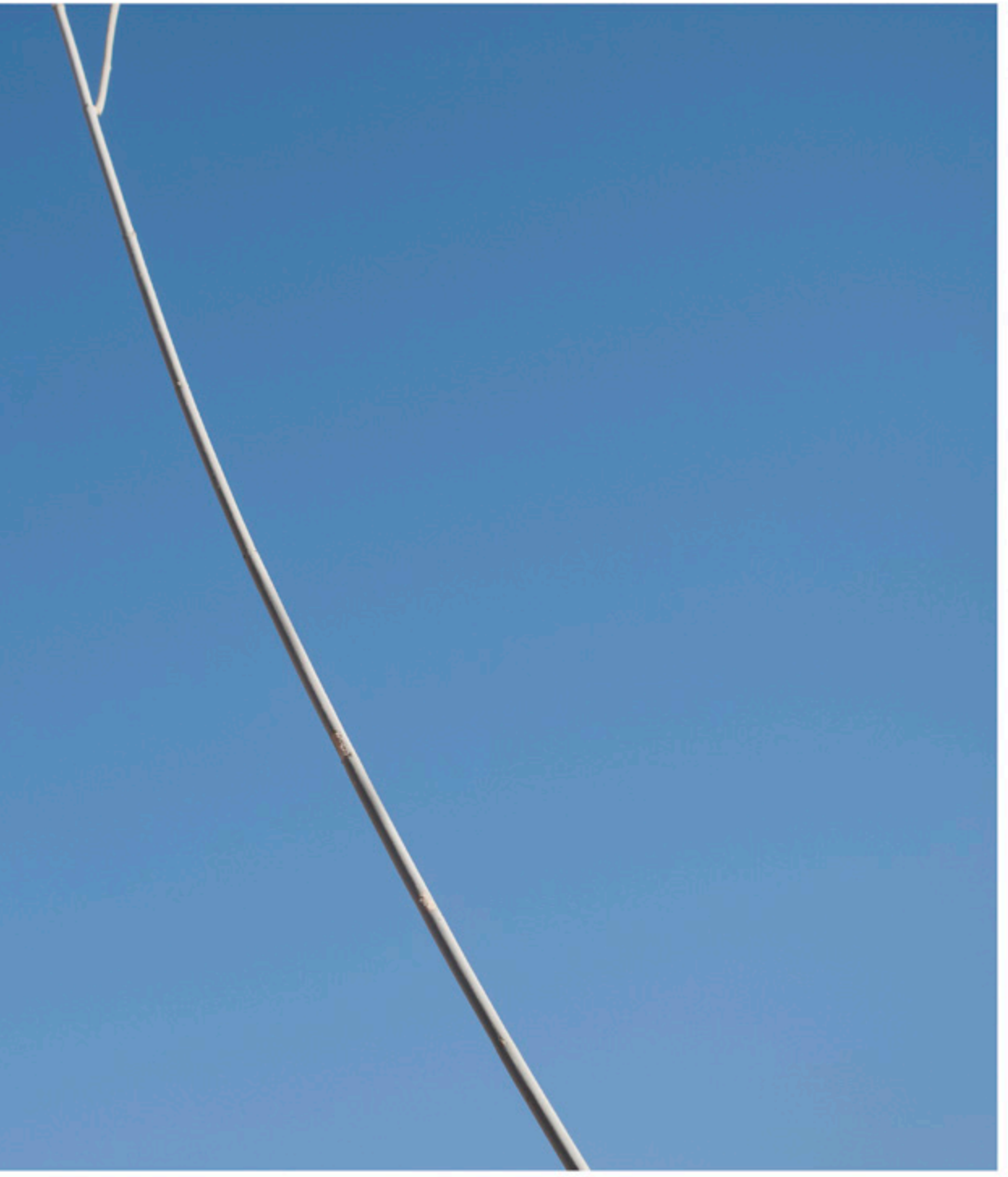
Desert plants are the winners of nature's lottery, products of a combination of fitness and improbable chance. Laugharn presents them on the page with the same sense of silence, spaciousness and clarity of air as you might find them in the desert. His pictures coax them out of the anonymity of their home ground into the spotlight of the lens and rightly exclaim, behold the miracles! ×

Visit http://www.richardlaugharn.com to see more of Laugharn's desert photographs.

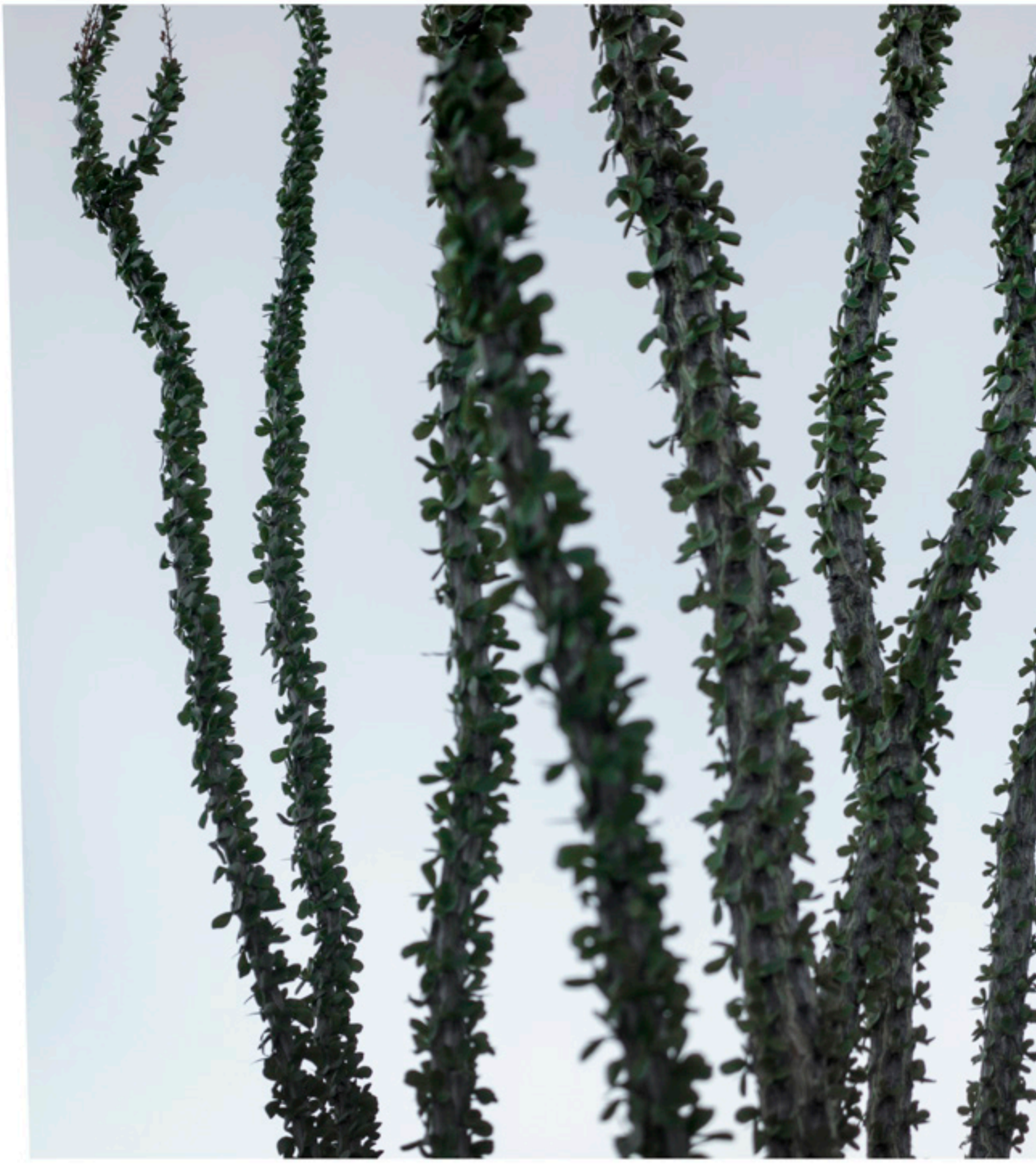
The Kofa Queen Saguaro (CG08 100425)
Richard Laugharn

The Sykes Crater Saguaro (CG03 140304)
Richard Laugharn





The Cabeza Prieta Milkweed (AA01 140317)
Richard Laugharn



The Copper Mountains Ocotillo (FS06 170203)
Richard Laugharn

Fog Harp field test prototype
Photo: Weiwei Shi

Article

Fog Harp: University invention to real-world impact

Brook Kennedy, Jonathan Boreyko, and Weiwei Shi

Fog Harp: University invention to real-world impact

Brook Kennedy, Jonathan Boreyko, and Weiwei Shi

Access to clean drinking water has quickly become one of the 21st century's leading humanitarian challenges. Numerous studies have issued dire warnings about the shortfall of safe drinking water supply in communities around the world. One study found that as much as two-thirds of the world's population currently face some form of water scarcity at least one month of the year.[1]

Designers and engineers around the world have been looking for new ways to access water or extend the usefulness of every drop. Among these solutions is fog harvesting, which collects fog, literally out of thin air, for human consumption. The World Health Organization has endorsed the cleanliness of fog water in many locations. For decades, fog harvesting has been used in areas of the world where little or no other drinking water alternative exists, all without using any energy. In some cases, fog harvesting has been used for small scale crop irrigation.

Canadian non-profit FogQuest, one of the leading pioneers of modern fog harvesting, has constructed numerous installations around the world, although there is some evidence that fog harvesting has been practiced as far back as the Incan Empire. Today, in countries like Chile, Guatemala, and others, FogQuest continues to advise communities in the construction, siting and maintenance of these devices. Similar in appearance to a volleyball net, fog harvesters often use a cross-woven mesh netting material that is suspended between vertical posts with supplemental cables to secure the structure against high winds. Beneath the mesh netting, a trough collects the captured water and funnels it into a barrel. Sometimes the water is piped downhill into a cistern where it can be located closer to the community it serves. Especially in small communities in desert regions like northern Chile and Morocco, fog harvesting has enabled residents to collect drinking water themselves rather than retrieve it from remote, often distant water sources. Frequently, it is women and children that busy their day with this arduous activity, limiting their ability to focus on other important tasks, like education.[2]

Fog harvesting has demonstrated that it can truly make a difference in people's lives, but the design of fog harvesters has evolved very little. There have been some explorations of new architectural structures - notably cylindrical, volumetric frames that suspend the mesh netting, but these studies have not fully justified their cost-benefit to improve water yield. On the other hand, more work is needed to understand how to improve the fluid dynamics of the mesh

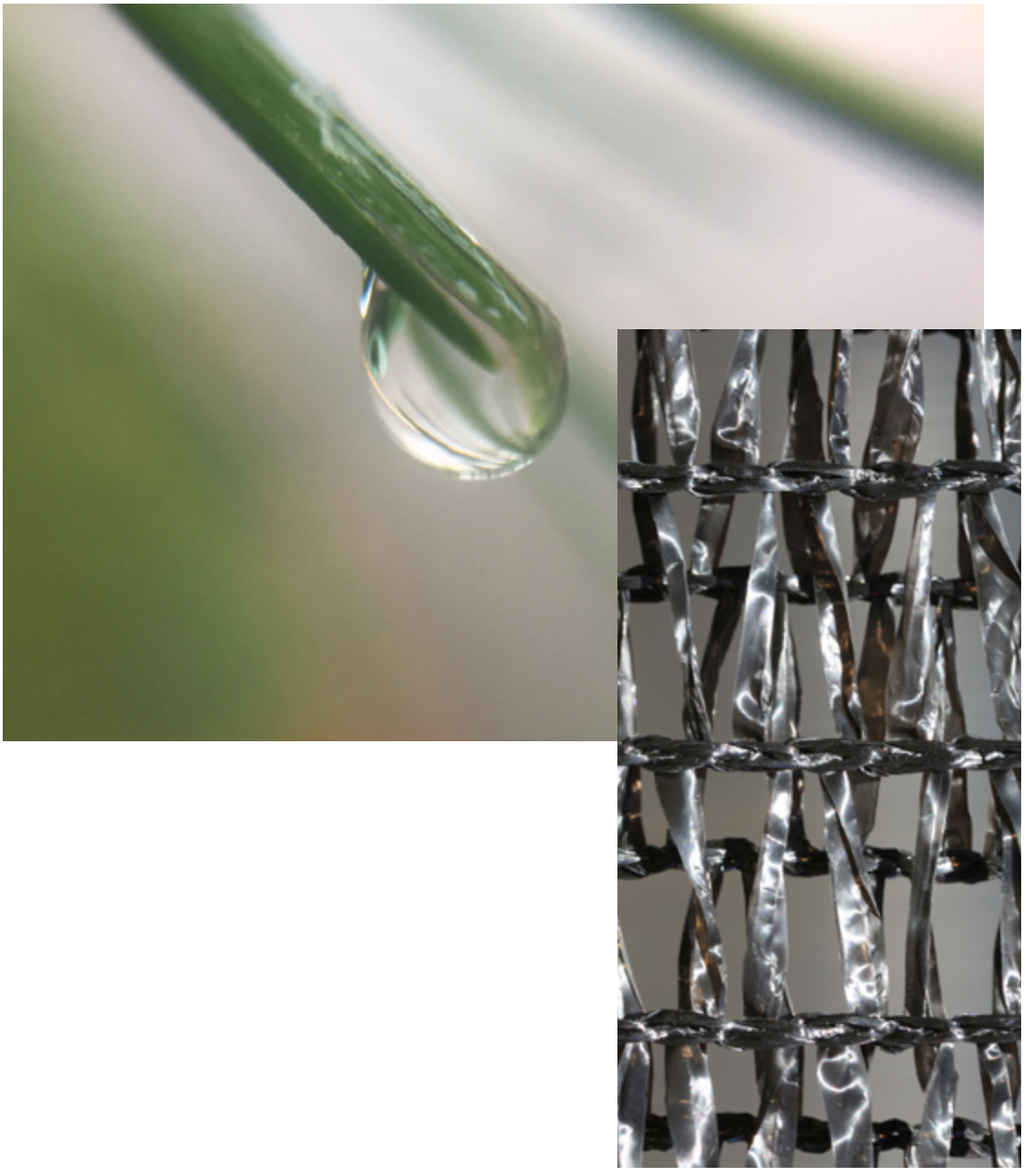


Figure 1. At left, a close-up view of a water droplet rolling off a pine tree's needle in Virginia. Photo by Brook Kennedy. At right, a close up view of woven polypropylene Raschel mesh. Photo by Weiwei Shi.

Fog Harp: University invention to real-world impact
Brook Kennedy, Jonathan Boreyko, and Weiwei Shi

netting itself. While some recent companies and NGOs have begun to develop alternatives to these materials,[3] the standard material used to collect fog remains cross woven mesh netting, particularly *Raschel mesh* (Figure 1), a woven polypropylene or polyethylene plastic material often used for crop transport and fencing.[4] Perhaps unintentionally, it was discovered that Raschel mesh was effective at collecting fog droplets, and it has continued to be used because it is cheap and available.

In 2015, Virginia Tech professors Jonathan Boreyko and I met at a Bio-Inspired Science and Technology (BIST) meeting and discovered our shared if slightly different fascination with fog harvesting. Dr. Boreyko, a mechanical engineer specializing in microfluidics, was interested in droplet behavior on structured surfaces since his doctoral work on condensation at Duke University. On the other hand, as an industrial designer and professor, I have been interested in bio-inspired design (BID) since my days developing consumer products for global brands full time. Earlier, I had also studied both biology and design at the college level. Independently, I have been interested in fog harvesting for some time and wondered if it could be more efficient to help water-starved communities worldwide, especially having spent a few years at Stanford observing fog in the San Francisco Bay area. At the time of the project's origination, California was falling into a severe drought and interest in water technology and management was on the rise. One foggy morning while jogging on a local Virginia trail in the mountains, I marveled at the droplets being captured by spider webs. In addition, I noticed how a local coniferous tree's linear needles seemed to attract fog droplets, which would then fall away (Figure 1). Later, I researched this phenomenon informally and learned about the natural phenomenon of fog drip, where Sequoia Sempervirens forests provide as much as 1/3 of their ecosystem's water intake from fog.[5]

Dr. Boreyko and I discovered we had similar suspicions about the limitations of conventional fog mesh netting, woven from both horizontal and vertical fibers. Dr. Boreyko often stated that cross meshes suffered from dual constraints: either meshes are too tightly woven and clogged with water droplets, or they are too loosely woven and excessive fog passes through the mesh uncaptured. What would happen if one could design a dense 'mesh' similar to conifers, without horizontal wefts that clog the droplets? The proposed fog mesh was no longer a mesh, it looked more like a fog 'harp,' hence the name of the project. After testing three miniature harp prototypes

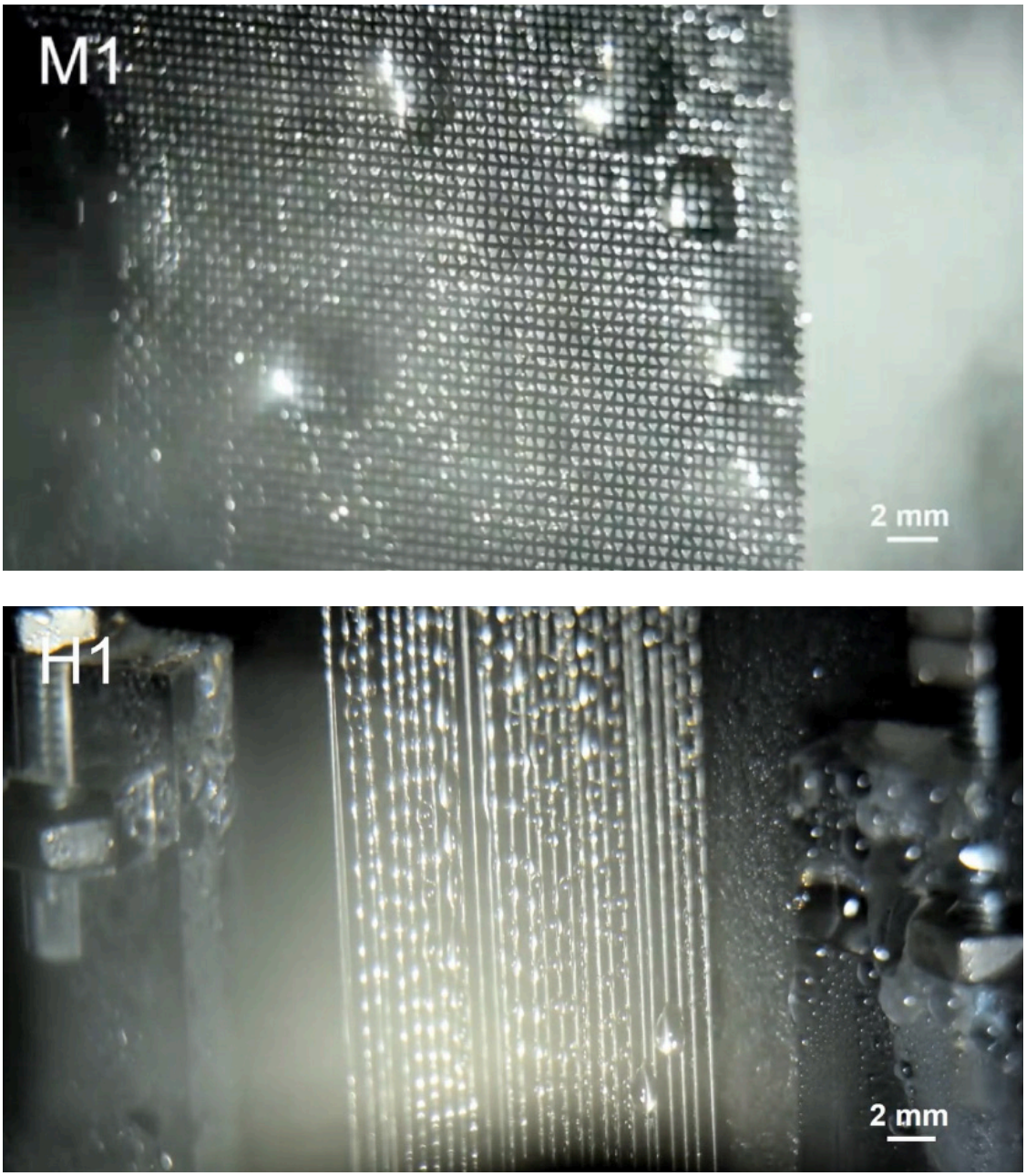


Figure 2. Top: video screen shot of simulated fog aimed at a roughly 1" x 1" cross woven metal mesh in controlled lab conditions. Bottom: a video screen shot of a comparable harp of the same measurements..

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and three correspondingly miniature cross meshes in a simulated fog stream, the performance advantage was clear: a dense harp out-collected an equivalent cross mesh 3 to 1 in water yield. The details of this discovery were published March 29, 2018 in *ACS Applied Materials and Interfaces*.[6] Just prior to the publication of the paper, we filed a provisional patent for the parallel wire material system. About a year later we filed a formal utility patent application which is still pending.

After the publication of the paper, the idea received considerable media coverage - inquiries from *The New York Times* along with pieces in the *BBC Newsday*, *PBS Newshour*, *The Boston Globe*, *CNN*, *The Washington Post*, *The Verge*, and many others. We were contacted by NGOs around the world, scientific colleagues, farmers in California, and even a winery. By that summer, we'd been approached by several investors and corporate partners including a large Middle-Eastern utility and a multinational brewing conglomerate. It seemed that water scarcity and fog harvesting technology were synchronized. Eventually we signed a partnership with an investment group, through Virginia Tech, to try to advance the project forward into potential commercial fruition. The partnership resulted in a several hundred thousand dollar, three year research contract. Since our initial internal startup grant was depleted, this sponsorship helped us with day-to-day financing - purchase of materials, prototype construction, hiring research assistants, and more. Over the course of a three-year research plan, we defined a goal: to iteratively develop and test Fog Harp technology in the field against known emerging "competitive" materials, and to explore how to mass produce parallel wire array harp meshes. The ultimate goal remains unchanged: to deploy a pilot installation of multiple harps in a real world location where a future, larger fog farm, like a solar farm, might be located. Possible locations include Peru, South Africa, the UAE, and others.

As of February 2020, we have reached the halfway point of the three year research program. In the fall of 2018, we erected two roughly 3' x 3' harvesters to test Fog Harp next to existing cross meshes in outdoor conditions. We were very lucky in two regards. First, we learned that the Blue Ridge mountains had adequately consistent moving fog to serve as a testing site, which meant we did not need to find a test location in some distant, hard to access place. Then, we were able to use a Virginia Tech-owned agricultural research farm. The farm's administrators also gave us a location that

was right next to a weather station with a camera, so we could observe if our Fog Harp was damaged or blew away (in November 2018 the region experienced a few days of high winds, gusting up to 70mph). Fortunately, when we deployed our basic Fog Harp prototype for testing, the design of the harp material did not "sail" like Raschel mesh, so we were able to leave it in place to collect data without much worry. Other than checking water yield measurements daily and to observe how the wires fared, little maintenance was required which allowed us to collect data for over a year. We installed this first field test Fog Harp just in time for the prime fog season, between fall and spring. We also constructed a wood-framed roof structure with standard roofing tile, to keep rain out of the harvesters - that way we knew we were collecting fog, not rain. We were not able to construct our first field prototype with the same wire spacing (pitch) and wire tension as the one we had tested in the lab. Where the earliest lab test had a wire diameter of 0.254 mm and a pitch-to-diameter ratio of 2, the wire spacing in the field test harp was larger so we figured it would not collect water optimally. The wires also loosened over time which only further diminished its potential performance.

Yet the over year-long data we observed from the field tests were tremendously encouraging; in some cases, far more than 3 times as much water yield compared with the cross meshes, in a variety of foggy conditions. On average, the Fog Harp collected anywhere from 2.3 to 19.5 times more water than the mesh structures, depending on the weather and choice of mesh. The preliminary results were shared in July 2019 at the International Fog and Dew Harvesting Association conference IFDA in Taipei, where we received great constructive feedback from fog harvesting specialists around the world.

By the fall of 2019 we divided our development tasks in two parts: *second round testing* and *mass production exploration*. This time around we wanted to test a 3' x 3' Fog Harp prototype with the same specifications as our best miniature lab-tested harp. We constructed the second round of Fog Harp prototypes far more robustly, with wire tensioning capabilities, to keep the wires tight and parallel. To test their efficacy, we contracted the Virginia Tech Transportation Institute (VTTI), a vehicular research facility, who had fog making machines that could spray controlled simulated fog onto the harvesters. These tests were conducted beginning in October 2019 at VTTI's test road which often serves large government

Fog Harp: University invention to real-world impact

Brook Kennedy, Jonathan Boreyko, and Weiwei Shi

Figure 3. At left, A minimal viable product Fog Harp small fog collector (SFC). At center, field tests of small fog collectors under a roof at Kentland Farm, Virginia Tech. The roof was added to keep rainwater from interfering with our data collection. At right, a closeup of the field test Fog Harp gathering water droplets.

and industry contracts to test autonomous vehicles and other futuristic technologies. There, after testing the newest fog harvesters, we gained even more nuanced insight about the Fog Harp technology (Figures 4a and 4b). Wire tangling, for example, impedes the performance of the Fog Harp while slight fluttering of the wires in the wind can help expedite the fog harvesting process: droplets are encouraged to fall away, thus allowing the wires to be ready to collect more droplets. Many of the details of this test are being documented for an upcoming scientific publication.

During the same period, we have also been looking at ways to mass-produce our Fog Harp material. Raschel mesh is produced using industrial knitting technology, which can rapidly fabricate rolls of mesh for fences and other purposes. To succeed, Fog Harps need to be able to be manufactured just as efficiently. While some interest in the technology has come from utilities with great resources, many other potential fog harvesting regions are remote and poor. To have the maximum impact on all communities that could benefit from the technology, the material and structure needs to be durable, cheap, and easily

Figure 4a. Fog machines on the Virginia tech Transportation Institute smart road where controlled round 2 field tests of small fog collectors (SFC's) were performed in October 2019. Bottom: an image of a round 2 Fog Harp under construction using an EDM cut metal comb to keep wires parallel.

transported to compete with the economics of Raschel mesh.

Currently we have discovered a few promising traditional lower-tech industrial processes to achieve this goal, but we are exploring others as well. Looking forward into 2020 and 2021, we are excited to combine our efforts in manufacturing and commercial viability with continued scientific testing in real world environments. This important milestone will determine whether Fog Harp technology might truly be adopted for human benefit.

There are significant challenges ahead, but so far a few basic characteristics of our team project have been instrumental in our forward momentum:

- **Purposeful Interdisciplinarity**: Though it might sound cliché, the interdisciplinary core of our academic team has been fundamental to Fog Harp's success so far. Our distinct disciplinary skillsets were well matched to the specific challenges of fog harvesting. Dr. Boreyko's and doctoral student Weiwei Shi's command of fluid dynamics and surface wettability brought rigor to the science of fog and water behavior on surfaces. Equally, my own practical design expertise helped find new ways to visualize, build and test these scientific hypotheses in the real world, in a manner that was grounded in human need, manufacturability, and cost-sensitivity. Sometimes asking 'dumb' questions across disciplinary boundaries unleashed significant advancements.
- **Efficient 'Good Enough' Prototyping**: The culture of producing quick, effective, low fidelity, "minimal viable product" prototypes might be widespread in Design Thinking circles in industry and parts of academia, but it is also critically needed in research science to translate lab discovery to practical, inventive results. Early prototypes don't need to be pretty (although this helps in the media) but they have to work so that important questions

Figure 4b. An image of a round 2 Fog Harp under construction using an EDM cut metal comb to keep wires parallel.

about performance and viability can be answered. Whether in industrial design, architecture, or elsewhere, more designers should engage to help make lab work testable, real, and ultimately accepted by the people who will benefit. Obviously, lots of design-engaged research activity has been underway for years culminating in maturing startups like Biomason and others, but greater participation and integration between research science and design would stimulate more impactful applied outcomes.

- **Institutional Support**: In recent years the concept of the "Entrepreneurial University"[7] or a third university mission supplementing instruction and research has been an influential backdrop for advancing Fog Harp. Like many other universities, Virginia Tech has recently revisited its research commercialization and licensing process, towards one that is more engaged with industry and external funding. This strategy has included increasing public promotion of research activity to external media outlets, which has consequently attracted external sponsorship for our research. Like other state funded universities, Virginia Tech is also committed to its service charter (*Ut Prosim*, "that I may serve"), which aligns perfectly with the humanitarian service-oriented mission of the project.

Nevertheless, a great deal of work lies ahead to adapt this technology so that it delivers results in the real world. How can we finance an enterprise that both delivers drinking water to those who need it while paying for itself? Many product and technology social impact startups, no matter how clever their ideas, have struggled to break even. Some have adopted "buy one, give one" strategies to redirect sales revenue in one market to subsidize another unprofitable one. If we want Fog Harp to have impact, we will need to have an open mind and nimble expectations to see it through. ×

The Fog Harp team would like to thank Virginia Tech, the Institute for Creativity, Arts and Technology, and Greenshift Corporation for their support.

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Brook Kennedy is an award-winning designer who also serves as an Associate Professor of Industrial Design at the College of Architecture and Urban Studies at Virginia Tech. There he pursues multiple research collaborations, including in bio-inspired design, with an eye on applied outcomes in social impact, human health and sustainability. Kennedy completed his graduate design work at Stanford University.

Jonathan Boreyko is an Assistant Professor at Virginia Tech in the Department of Mechanical Engineering. Dr. Boreyko received his Ph.D. in Mechanical Engineering and Materials Science at Duke University followed by a postdoc at the Oak Ridge National Laboratory. His research lies at the intersection of fluid mechanics, phase-change heat transfer, and materials science. In particular, Dr. Boreyko specializes in developing biomimetic systems that exhibit novel condensation, evaporation, frosting, or water harvesting phenomena.

Weiwei Shi, is a PhD Candidate of Engineering Science and Mechanics, Virginia Tech, working in the Nature-Inspired Fluids & Interfaces (NIFI) Lab led by Dr. Jonathan Boreyko.

We would appreciate your feedback on this article:

FrancaDora

Portfolio

Fraenzi Neuhaus

Portfolio
Fraenzi Neuhaus

Fraenzi Neuhaus works in drawing, sculpture, and installation. Neuhaus's work over the past few decades has moved from textiles to high-tech fibers, materials more commonly found in medical engineering, in telecommunications and space technology. The following **is an excerpt from** *FadenWerke* **by Patricia Bieder, translated by Chris Walton.**

In her apartment in Solothurn, Neuhaus has a large collection of cicadas; other insects and skeletal fragments of small animals are also lined up. Seeds and plant shells lie in bowls. On the tables stand numerous terraria in which the artist cultivates plants she has nurtured herself. Neuhaus's first career was as a scientific draughtsman, during which time she acquired a large body of knowledge about the natural sciences. On her bookshelves there are exhibition catalogues and many photo books alongside scientific publications about pollen, blossoms and insects.

Fraenzi Neuhaus

In the installation Eingenistet ("Nested"), Neuhaus is concerned with the tension and form that are necessary for her objects in order for them to appear as delicate as they are stable, and as firm as they are transparent – in fact, these same questions occupy her throughout her oeuvre. She creates structures and meshworks that she then positions or binds together to create spatial forms. She works with the tension inherent in the materials themselves, and by consolidating their forms she succeeds in imparting a sense of vigor to them. It is impressive how she uses synthetic materials to create structures derived from Nature that at times are reminiscent of biological systems. By using technical materials, especially plastic tubing and glass fiber cables, Neuhaus points to a further act of "cross-linkage": for example, the plastic tubing that Neuhaus uses for Eingenistet 47.3508°/7.9028° was developed to protect the glass fibers that are laid underground and enable us to engage in digital communication. Thus Eingenistet does not just awaken associations extending into the realm of Nature, but also asks questions about real and virtual networks, about communicative connections and societal interconnectedness. The notion of a flow of information and energy exchange finds its echo in the woven structures of Neuhaus.

Die Hüllen ("Shells") offer associative potential and yet remain abstract in their formal appearance. Neuhaus's works are never unambiguous, and yet their connection to natural forms is evident without their having to be fixed in that specific context. These "shells" arose from textile filter materials – in other words, from a predetermined, structured mesh that is reinforced and overlaid by being stitched down.

Fraenzi Neuhaus's material research and her interest in the topic of transformation recently led her to filament made of a thermoplastic resin with which she has created the work series Fioranica and Wandlung/ Transformation. These filigree, biomorphic structures are reminiscent of buds, blossoms and shells. The synthetic objects are situated alongside "real" larvae, buds and insects in Fraenzi Neuhaus's chamber of wonders, and urge one to study and reflect on our relationship to Nature. And they also sensitize our perception of how complex natural forms can be – and at times how surprisingly technological they can seem. In their form, the filament objects are not a depiction of natural reality, but an interpretation on the part of the artist, who in each case has to react immediately to the melted resin and give it form. In this process,

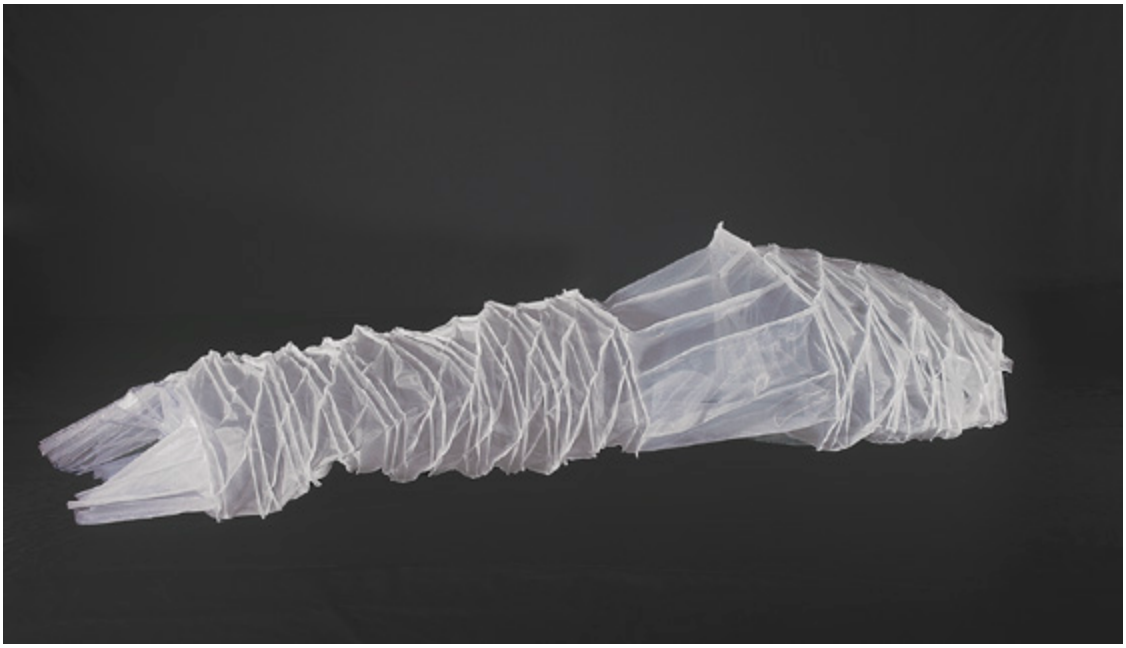
Fraenzi Neuhaus speaks about her visual art
https://www.youtube.com/watch?v=zHR-IUaPO4c&feature=emb_logo

Eingenistet/Nested 47.3508°/7.9028°

Portfolio
Fraenzi Neuhaus

the artist responds to the material and its innate tensions. The results are essentially also drawings in space: drawn objects that have been brought into three-dimensional form. Neuhaus's working method here, too, is characterized by a natural finding process, and by a balance between transparency and density, lightness and fullness, the abstract and the concrete. The filament, once cooled down, comes across as delicate and fragile. Creation and change, the living and the lifeless, the artificial and Nature itself are all written into these objects.

"Filament" comes from the Latin "filamentum," meaning threadwork. "Filament" in general means a fiber of unlimited length. We also find the concept in astronomy, meaning the large, thread-like connections that create the structure of the Universe along with the empty voids. This concept is as comprehensive and poetic as it is abstract, and on a small scale it can be applied to the artistic oeuvre of Fraenzi Neuhaus, whose threads in all their materializations create bridges between artificiality and naturalness, and thus connections and interlinkings that are



Die Hüllen/Shells

full of energy and want to be experienced. Neuhaus succeeds in making dynamic structures that bear the potential of transformation within them. Using the most modern materials, she develops meshworks that are reminiscent of unendingly growing structures, and in which the cosmic filament also resounds.

How does nature influence the way you see the world? Do you feel that you see things around you differently?

Wie beeinflusst die Natur die Art und Weise, wie Sie die Welt sehen? Hast du das Gefühl, dass du die Dinge um dich herum anders siehst?

I've always been fascinated by morphological structures, the way biological systems are organized. My interest focusses on the metamorphosis – it's not a simple matter of seeing and observing, but of understanding the process of change in the sense of development. I feel that my way of seeing nature influences all other parts of life – politics, social structures, music, etc.

Die Hüllen/Shells

Portfolio
Fraenzi Neuhaus

Who/what inspires you creatively? What do you "feed" on the most?

Wer/was inspiriert dich kreativ? Wovon ernähren Sie sich am meisten?

My basic interest in *organismus* is combined with an acute fascination for new techniques in science and biology, with new material. It`s a circle of “given” structures and innovative material research.

What are you working on right now? Any exciting projects you want to tell us about?

Woran arbeiten Sie gerade? Haben Sie spannende Projekte, von denen Sie uns erzählen möchten?

At the moment I'm working with filament, a 3-D technique of drawing with an endless plastic thread (PLA) – I'm trying to establish a connection to these innovations in order to understand their impact on our environment.

What is the last book you enjoyed?

Was war das letzte Buch, das Ihnen gefallen hat?

Barbara Beuys - *Maria Sibylla Merian. Künstlerin, Forscherin, Geschäftsfrau,* 2016.

Paul Starosta *Samen - Von der Schönheit des Ursprungs*, 2016

Rob Kesseler *Seeds - Time Capsules of Life*, 2014

What are your favorite websites, and why?

Was sind Ihre bevorzugten Websites und warum?

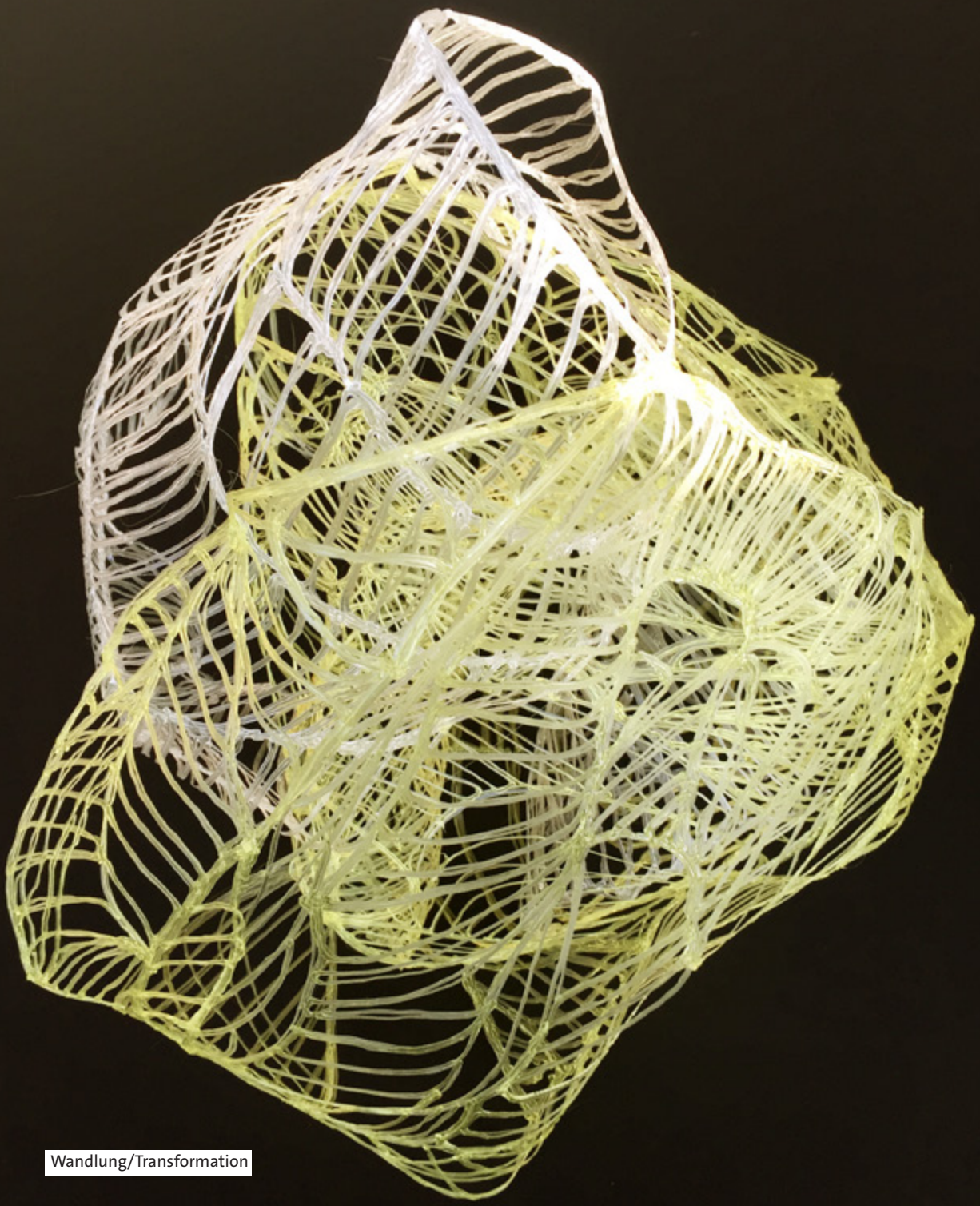
Tony Cragg: https://www.tony-cragg.com, his sculpture and its transformations.

Julian Sartorius: https://www.juliansartorius.com/audiovisual-works/morph, the connection between drawing and music. ×

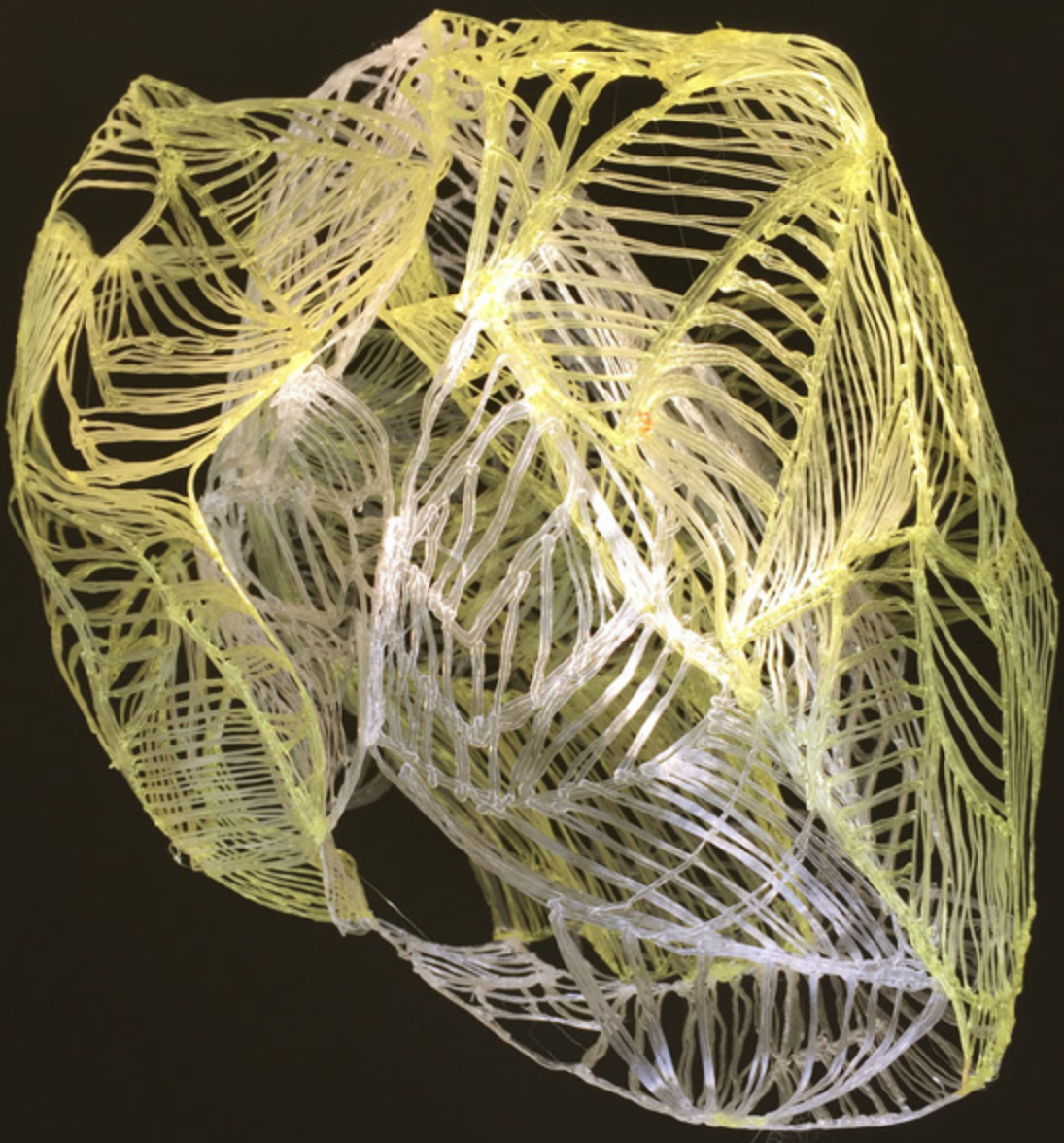
We would appreciate your feedback on this article:

Fioranica

Fioranica



Wandlung/Transformation



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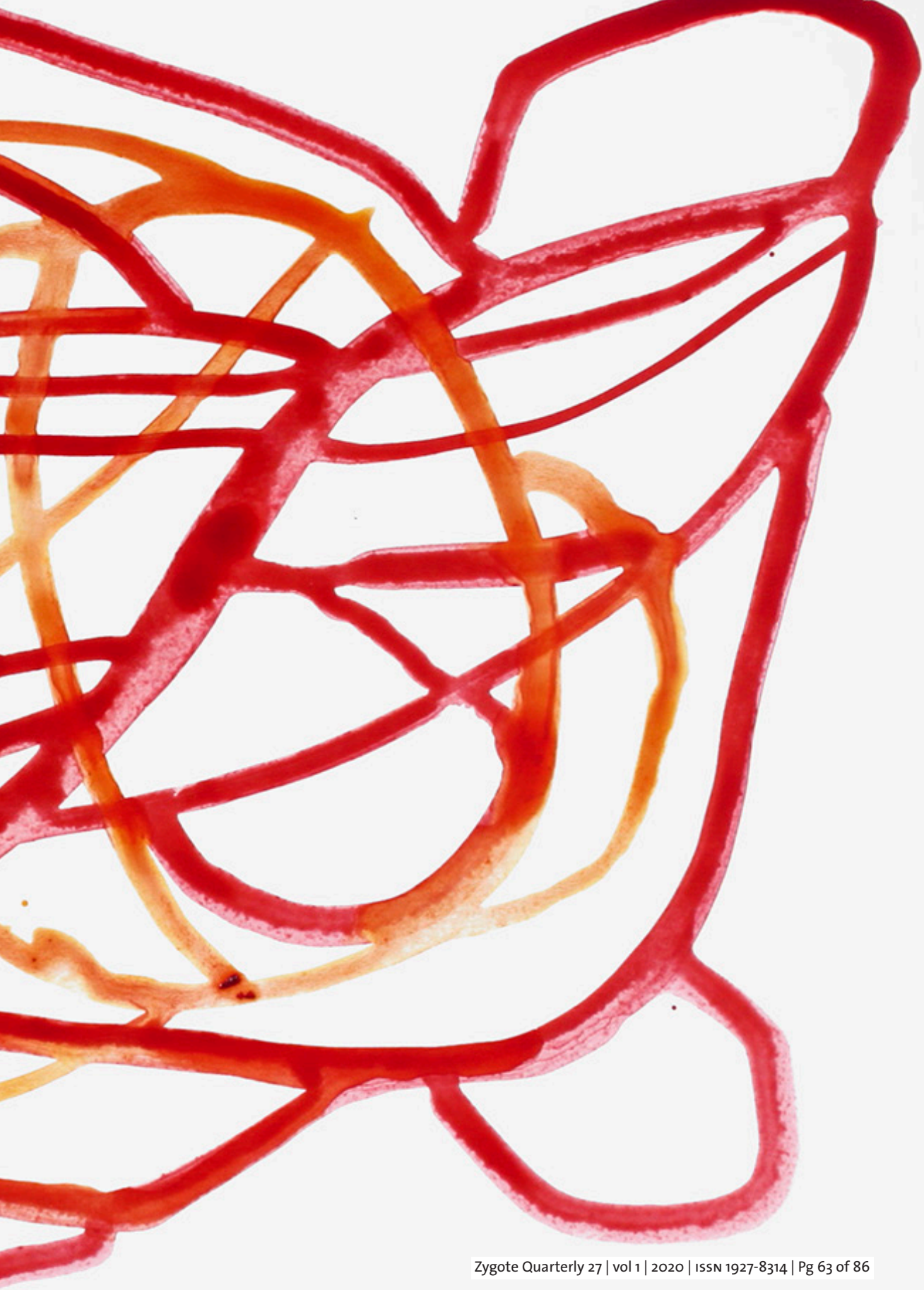
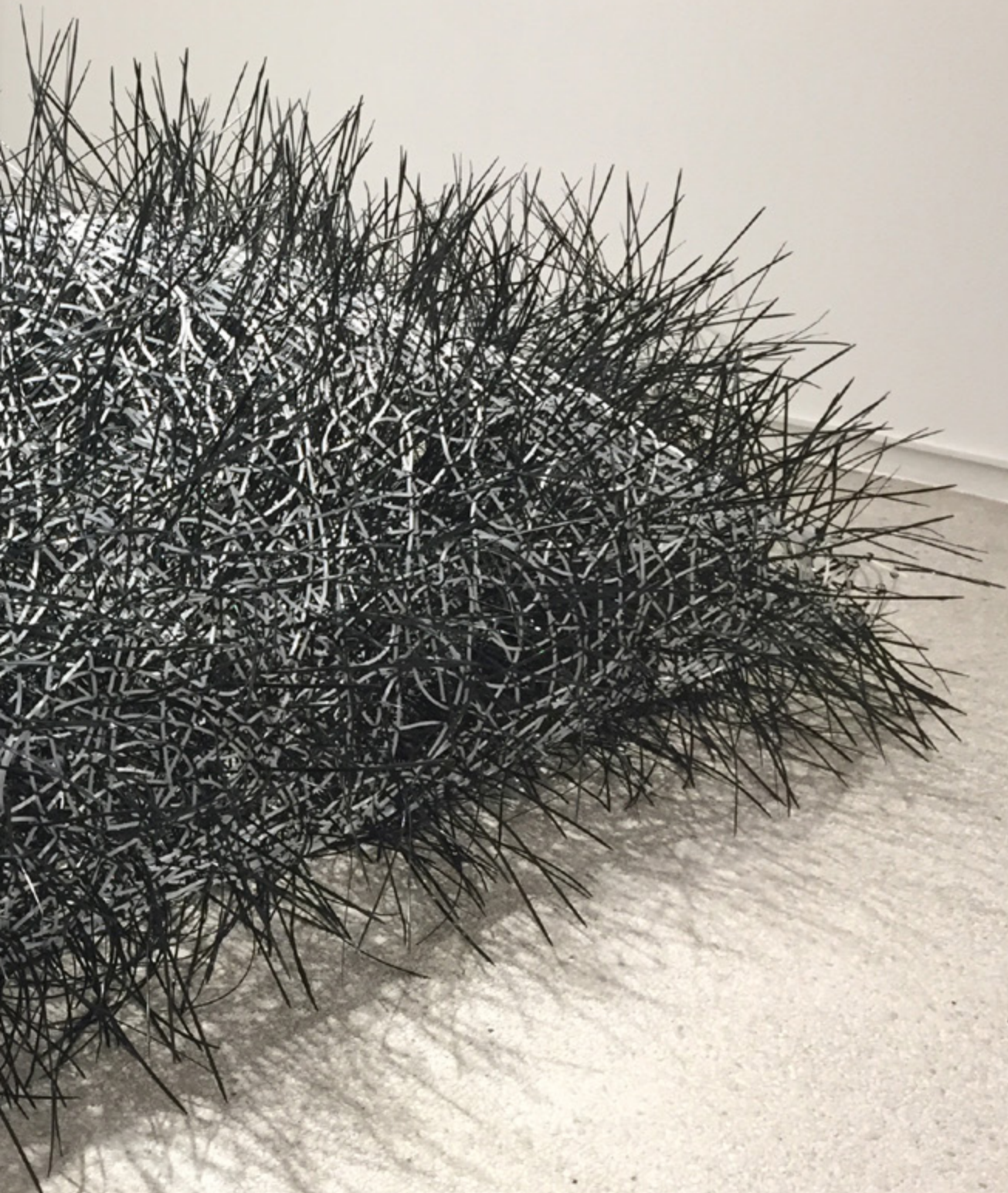




Delft (detail)
Photo: bertknot, 2007 | Flickr cc

Report

The Delft Workshops

Norbert Hoeller

The Delft Workshops
Norbert Hoeller

The Biomimetic Innovation in Business Survey

With the help of Pete Foley, Michael Helms, and myself, Julian Vincent surveyed about 440 people largely drawn from his LinkedIn contacts who had business connections and were interested in biom* (an umbrella term for biomimicry, biomimetics, and bio-inspired design). We received 106 responses - although the response rate was much higher than we had expected, we surveyed a relatively small pool of hand-selected people that are unlikely to be representative of the broader biom* community.

About 60% of the respondents indicated they were associated with small businesses, with the rest evenly distributed between medium and large businesses. There were relatively few differences across the three groups in terms of awareness, usage, stage of development, and evaluation of biom*, with the exception that all the commercial ventures occurred in small businesses.

The survey included free-form questions on the inhibitors and enablers of the practice of biom*. The results were diverse, and few clear patterns emerged. Although most of the respondents were positive about biom*, many comments suggested a sense of frustration. Barriers to adoption included concerns about the credibility of biom*, inadequate translation skills, and low business acceptance (the perception that biom* competed with existing innovation processes and difficulties relating to business insiders/decision makers).

One way of better understanding and overcoming these barriers is by building strategic partnerships outside of biom*. Julian Vincent had received positive feedback on a keynote presentation he gave at the Design Society (DS) in 2017. He proposed a DS Biomimetics Special Interest Group (SIG) that would:

- Examine the relationship of biomimetics to current design protocols.
- Integrate biomimetics as a standard component of accepted design practice in an objective and practical manner.
- Communicate the benefits of biomimetics in a manner consistent with industry priorities rather than the oft-quoted improvement in inspiration or creativity.
- Build and analyse a repository of industry case studies to validate and refine the SIG findings.

The DS asked Julian to organise a three-hour initial workshop at the International Conference on Engineering Design (https://www.iced19.org/) on August 5/2019 in Delft (The Netherlands) to assess interest in the SIG. To prepare for the meeting,

Julian formed a working group of about 40 volunteers from the biom* community that decided to create four teams:

- Credibility of biomimetics in business/ industry.
- Ability of biomimetics practitioners to deliver reliable/scalable solutions.
- Creating partnerships.
- Conceptual model of biomimetics.

Numerous conference calls among the team leads explored a wide range of topics but struggled to develop a consensus on how best to approach the August 5th ICED19 workshop.

The BiomimicryNL Delft Workshop

To help gather input from a broader audience, Saskia van den Muijsenberg of BiomimicryNL arranged an August 1st

Figure 1. An Open Space Technology team

The Delft Workshops

Norbert Hoeller

workshop at the Delft Botanical Garden with the provocative invite:

"Some say biom (an umbrella term for biomimicry, biomimetics, bio inspired design, etc.) is just wishful thinking and a path of creative marginality. Will biom* evolve to survive or just die as a short-lived hype of inspiration?"*

The workshop attracted about 30 participants from a broad range of fields and interests. To increase engagement and explore a wide range of perspectives, Saskia engaged a professional Open Space Technology (https://en.wikipedia.org/wiki/Open_Space_Technology) facilitator who helped the participants self-organise (figure 1) and discuss topics relevant to the compelling question "What would make biomimicry the most implemented methodology delivering meaningful results?".

The workshop started with group exercises which established a consensus that we need to listen, connect, and integrate rather than "push the concept". One participant commented afterwards that "we need

Figure 2. Discussion topics

experts on communication, process work, PR and entrepreneurship to make the next step." For the rest of the day, the facilitator organised three rounds of team discussions, with roughly six teams in each round (figures 2 and 3). The teams gave quick updates to the total group after each round.

Although all the teams had spirited discussions, my sense was that the teams struggled to address fundamental issues inhibiting the practice of biom* and instead focused largely on internal issues related to 'means' without connecting these means to meaningful 'ends'. The exception was one team that looked outwards and explored how biomimetics could be integrated with existing design processes (figure 4). Although biomimetics is often associated with ideation, the team suggested it can provide value at multiple stages of design. This team started in round two and continued developing their ideas in round three.

Figure 3. Discussion groups (additional teams)

The Delft Workshops

Norbert Hoeller

Preparation for the Design Society Workshop

Julian and I met on August 2nd and 3rd to prepare for the August 5th DS Biomimetics SIG workshop. Our initial thought was to provide an overview of biom* before discussing what it would take to increase adoption of biom* by business and industry. An example was Prof. Ferdinando Rodriguez y Baena's flexible and steerable endoscope for brain surgery, inspired by the wood wasp ovipositor that can drill into wood with near-zero insertion force. Although the typical biom* presentation leads with the biology and ends with the technology, some audiences may be better persuaded by starting with the benefits of the technology and closing with the inspiration for the idea.

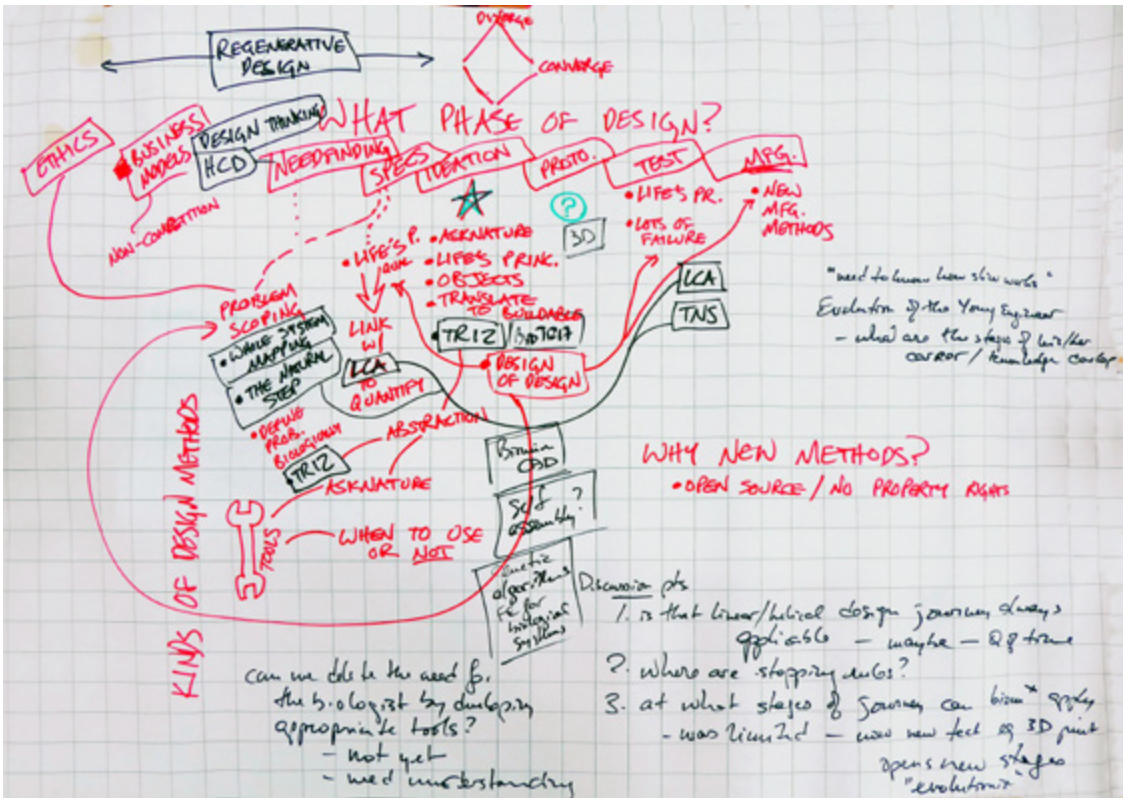


Figure 4. Integration with design methods

Even though the first DS Biomimetics SIG workshop was likely to attract people interested in the concept of biom*, we decided to try the 'biology last' approach by leading with issues of general interest to designers and then exploring how biom* might help address those issues. Julian and I discussed some ideas on how biom* could evolve to be more accessible to a wider audience (table 1).

The Design Society Biomimetics SIG Workshop

About 30 DS members attended the ICED19 August 5th workshop. Most had an engineering background with one or two from

Table 1. Evolution of biom*

	Biom* v1	Biom* v2
Inputs	phenomena/organisms/species	design principles/strategies
Process	promote concept	address real world challenges
	talk about biom*	listen to discover unmet client needs
	solution driven	more problem driven
	knowledge transfer	knowledge transformation, organisation, and translation
	identify biom* solutions	re-frame problems
	Serendipity (low yield)	structured approach (higher yield)
	promoting the concept of biom*	practicing biom* to deliver meaningful, reliable, and scalable results
Integration	inwardly focused	engage diverse strategic partners
	standalone innovation process	leverage existing design, innovation, and portfolio management processes
Outcomes	product solutions	systems implications
	leading with nature	balance human/social, environmental, and economic aspects
	quieten human cleverness	spark and guide human creativity
	static solutions	dynamic/fluid solutions

The Delft Workshops

Norbert Hoeller

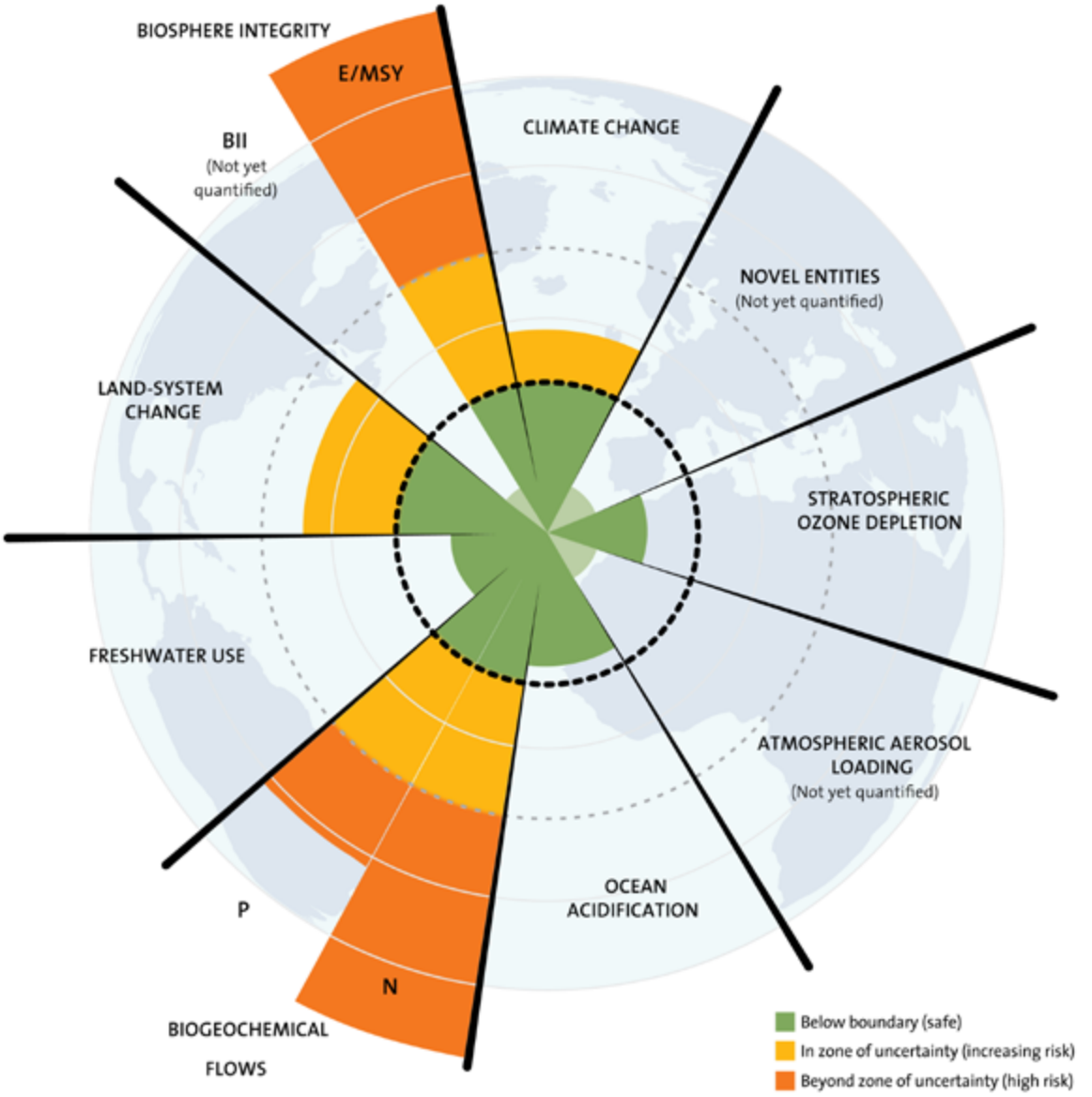


Figure 5. Key Planetary Boundaries and their 2015 risk levels (credit: J. Lokrantz/Azote based on Steffen et al. 2015)

biology, mathematics, physics, sustainability, and architecture. Julian opened the workshop with a chart on Planetary Boundaries (https://www.stockholmresilience.org/research/planetary-boundaries.html, figure 5) and the role of responsible design to keep us in the 'green zone', suggesting that just as design practice has incorporated human-centred design, it was time to consider environmental benefits while still enabling businesses to make money.

Julian presented his Royal Society charts (https://royalsocietypublishing.org/doi/full/10.1098/rsif.2006.0127, figure 6 and 7). Whereas technology typically emphasises materials and energy, biology tends to use information and structure. Given the growing concerns about our consumption of natural resources and fossil fuels, these charts are both a challenge and an opportunity to rethink our approach to design. Julian closed his talk by contrasting the ad hoc nature of typical biom* design with a more analytical approach based on network analysis and his work with trade-offs.

Eighteen workshop attendees returned after the break and agreed to join the DS Biomimetics SIG. They split into three working groups to explore the role of biom* in design, challenges and opportunities for biom* designers, and integration of biom* in design. Figure 8 graphically captures the key points of the workshop.

Follow-on Activities

We have a Biomimetics SIG steering committee comprising the leads from the original four teams and three Design Society members, along with Julian and myself. Based on discussions with DS leaders, we face a number of challenges to getting the Biomimetics SIG approved. DS SIGs normally form organically around topics of mutual interest. So far, we have identified 121 DS papers relating to biom* representing 269 authors, so the biom* concept is not foreign to the DS. Questions have also been raised about the 'fit' of biom* within the DS - we are the only SIG it does not have 'Design' in its name. There may be a perception that we are trying to impose our perspectives, which is contrary to the collegial approach that is a hallmark of the DS.

We are exploring synergies between the Biomimetics SIG and the existing DS SIGs. Including the original team members who were already DS members, we have Biomimetics SIG members on 11 of the 14 existing DS SIGs. The next steps are to find out what activities these SIGs are engaged in, look for trends across DS SIGs that can help articulate the relationship of biom* to broader DS initiatives, and work

The Delft Workshops

Norbert Hoeller

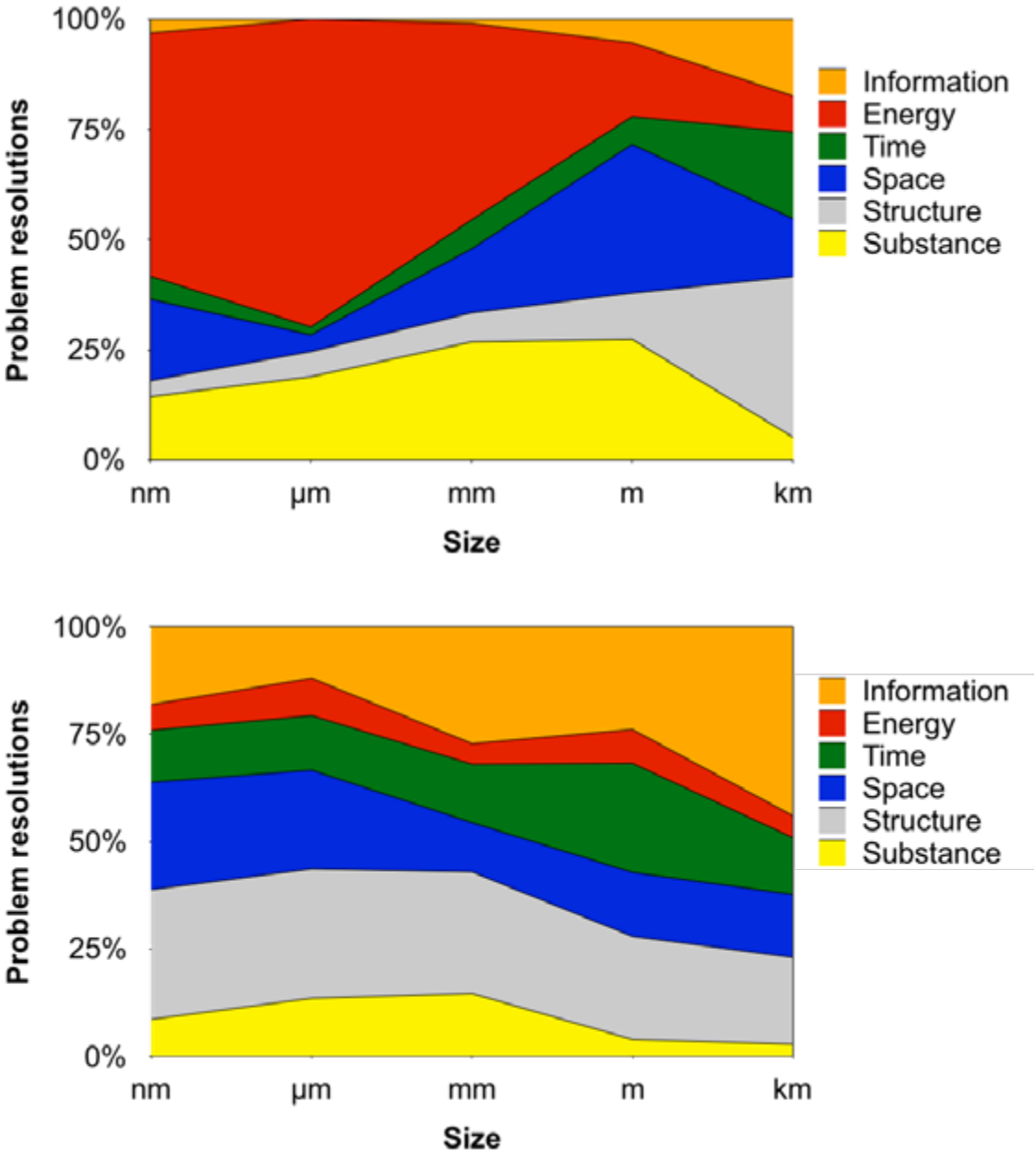


Figure 6 (top). Engineering TRIZ solutions arranged according to size/hierarchy (Vincent et al. 2006) (TRIZ or "Theory of Inventive Problem Solving" is a Russian-developed tool derived from patterns found in patent literature.)

Figure 7 (bottom). Biological effects arranged according to size/hierarchy (Vincent et al. 2006)

with relevant DS SIGs to explore mutual opportunities. Julian has been reading the 121 DS papers related to biom*, looking for patterns and exploring opportunities for defining a unique role for the Biomimetics SIG within the DS, such as developing a research agenda and engaging designers to improve study proposals. We are exploring a meta-study of papers describing biom* successes to help us better document the value of biom*. As we explore the breadth of the DS, we are also looking for outreach and partnership opportunities.

Developing a partnership with the DS will help us define a credible and compelling rationale for biom* relevant to the broader design community. To be successful, we need to:

- Be inclusive of the diversity of DS perspectives.
- Promote open discussion and debate.
- Act as a focal point encouraging interdisciplinary exploration of the relationships among design, natural systems, and technological systems.
- Create opportunities for purposeful and mutually beneficial engagement among designers, biologists, and other experts.

The DS Biomimetics SIG will help us understand the relationship of biom* within the evolving practice of design by providing a focal point for related DS initiatives such as design for the environment, multi-species design, and ecological design. In addition to facilitating the transfer of knowledge from nature to technology, the SIG can explore an engagement model such as “place-specific design" that incorporates understanding the environmental implications and designing for environmental contexts. The SIG can help identify and guide initiatives that show promise in enabling meaningful and evidence-based innovation. By exploring the relationship of biom* within the evolving practice of design, the SIG will strengthen trans-disciplinary collaboration required to deal with complex situations spanning the domains of design and nature. ×

We would appreciate your feedback on this article: 

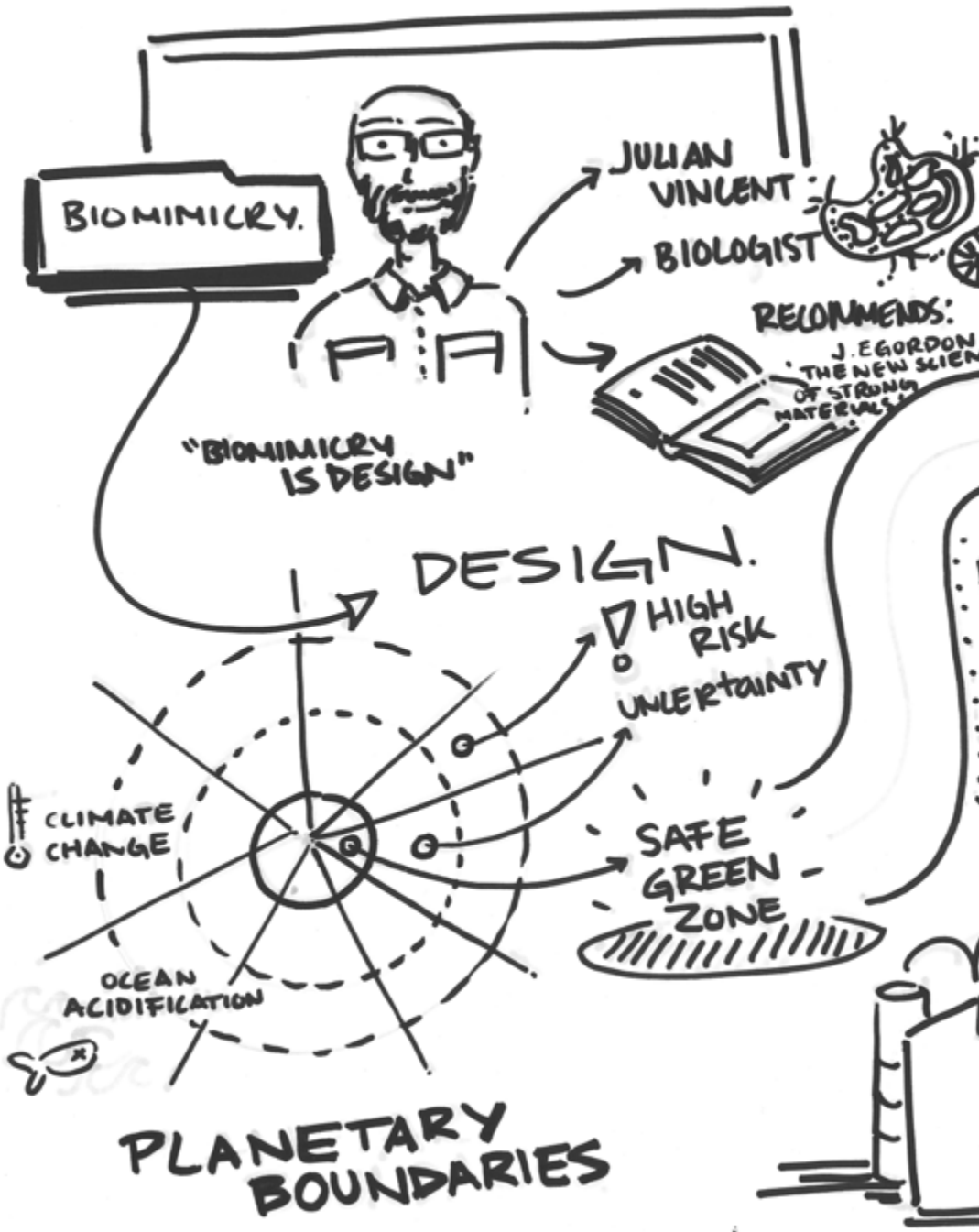
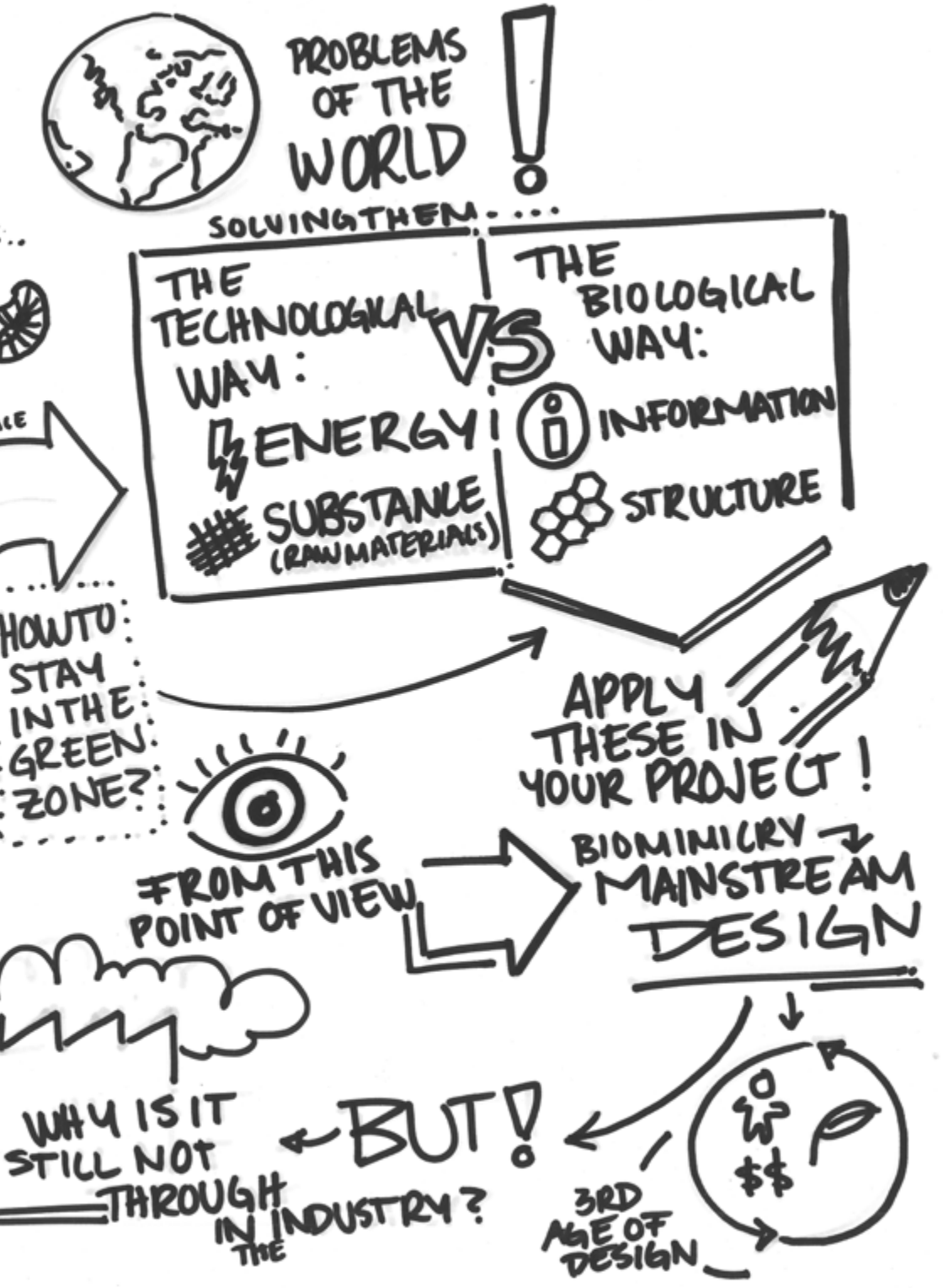
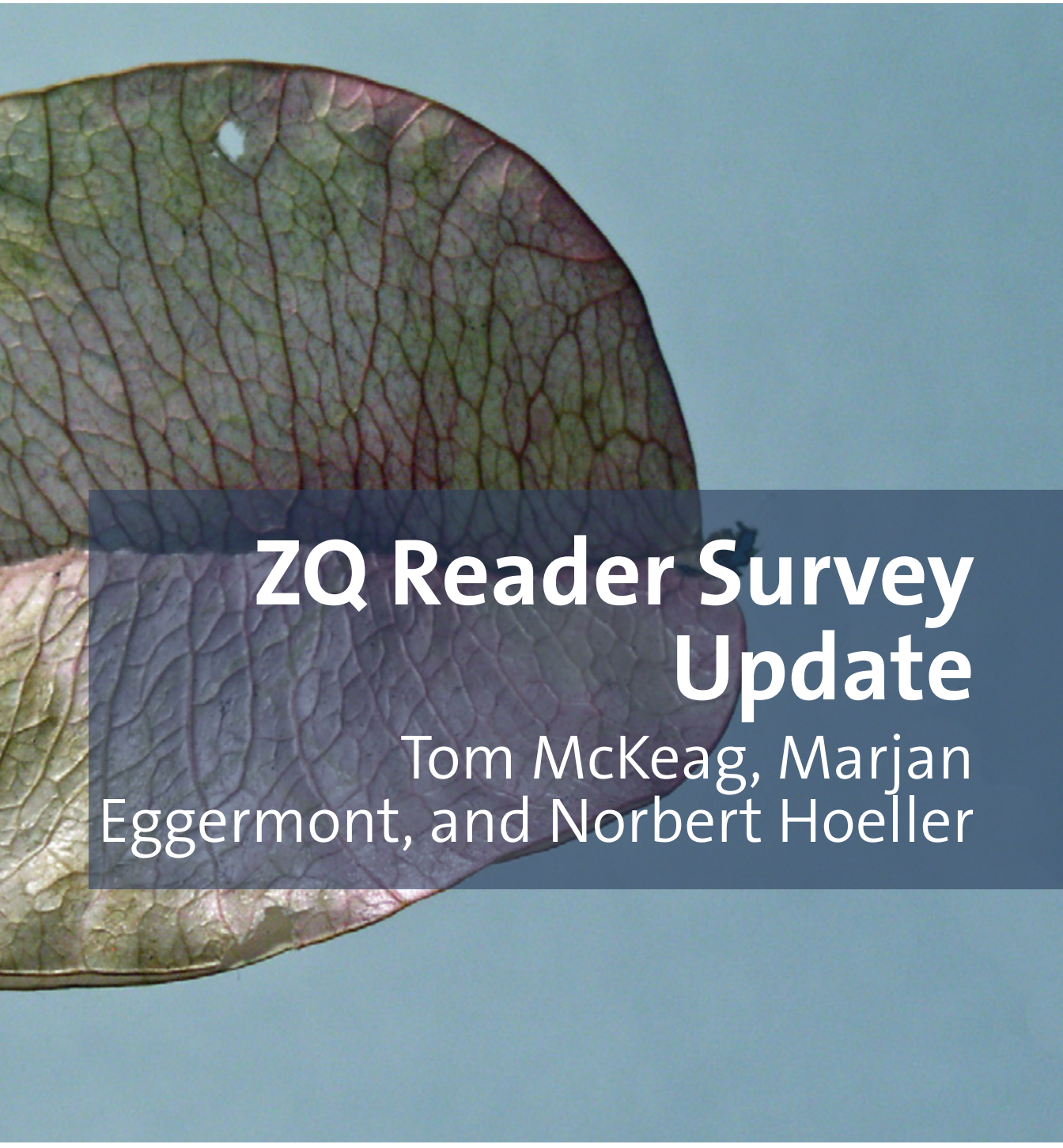


Figure 8. Overview by a roving Design Society reporter


PROBLEMS OF THE WORLD !
SOLVING THEM ...
THE TECHNOLOGICAL WAY:
ENERGY!
SUBSTANCE (RAW MATERIALS)
VS
THE BIOLOGICAL WAY:
INFORMATION
STRUCTURE
HOW TO: STAY IN THE GREEN ZONE?
APPLY THESE IN YOUR PROJECT!
FROM THIS POINT OF VIEW
BIOMIMICRY → MAINSTREAM DESIGN
WHY IS IT STILL NOT THROUGH IN THE INDUSTRY?
BUT!
3RD AGE OF DESIGN

Seed pod
Photo: Night Heron, 2006 | Flickr cc



ZQ Reader Survey Update

Tom McKeag, Marjan Eggermont, and Norbert Hoeller

ZQ Reader Survey Update

Tom McKeag, Marjan Eggermont, and Norbert Hoeller

Although ISSUU provides extensive statistics about ZQ impressions/views/clicks, we wanted a way to directly engage with our readers. Starting in ZQ23, we included thumbs up/thumbs down symbols at the end of every article. Clicking on the symbols would bring up a one-page survey pre-filled with the article name and the symbol selected, with the option of changing the rating and providing a comment.

ISSUU counts a read if the readers opens the publication and stays for more than two seconds or interacts with the publication.

We did a preliminary analysis grouping articles by type or theme. "Stories from the Trenches" includes the last in the ZQ21 to ZQ23 series as well as the subsequent "Perspectives" articles. The table is stored in descending order of "Yes" ratings divided by the number of articles. One surprise was the lack of survey responses to the two interviews. The small number of comments precluded any analysis of the comments. Some of the comments generated interesting discussions among the editors and may lead to future articles.

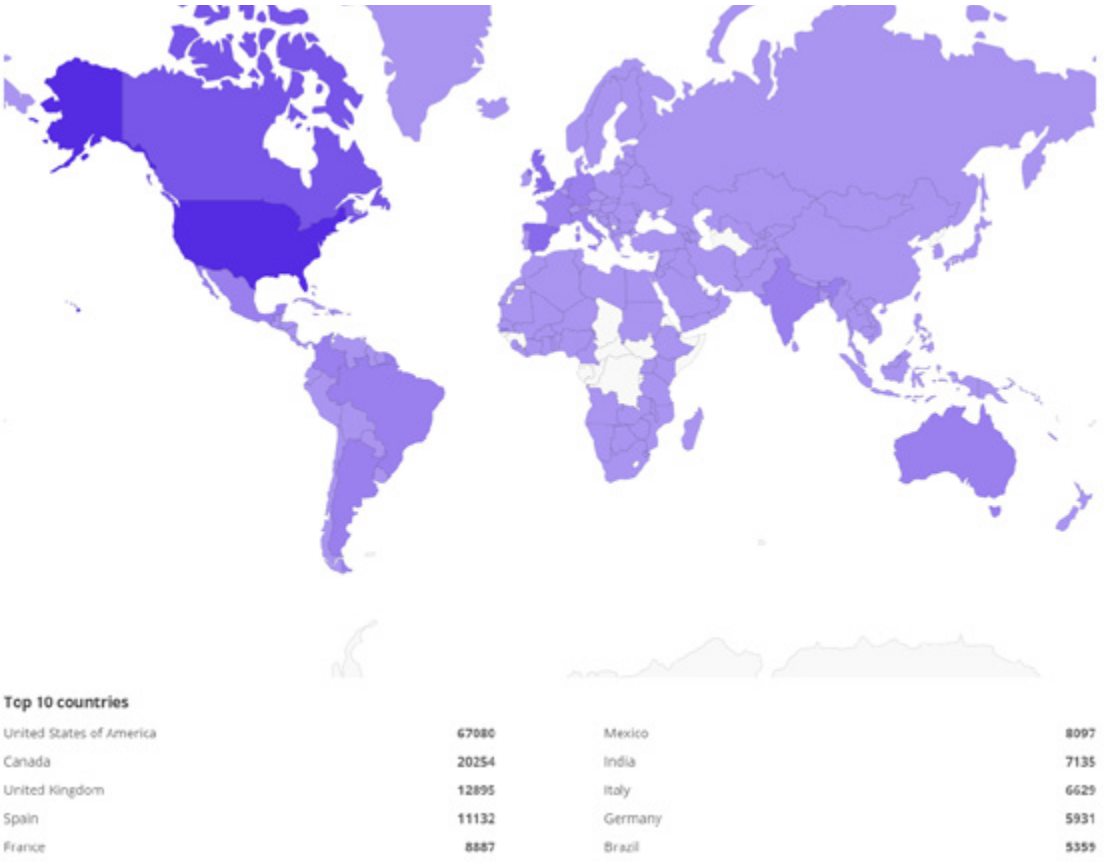
Issue	ISSUU Reads	Survey Responses	Yes	Maybe	No	Comments
ZQ23	3866	34	33	1	0	6
ZQ24	2550	37	36	0	1	12
ZQ25	2260	36	36	0	0	6
ZQ26	1417	26	26	0	0	7

The declining ISSUU Reads from ZQ23 to ZQ26 is probably related to the time since the issue was published. The number of survey responses is quite small compared to ISSUU Reads but very positive, with one 'Maybe' associated with comment of a technical nature and one 'No' without a comment. We see an average of six to seven comments - the larger number in ZQ24 was due to eight comments on "You Crack Me Up!".

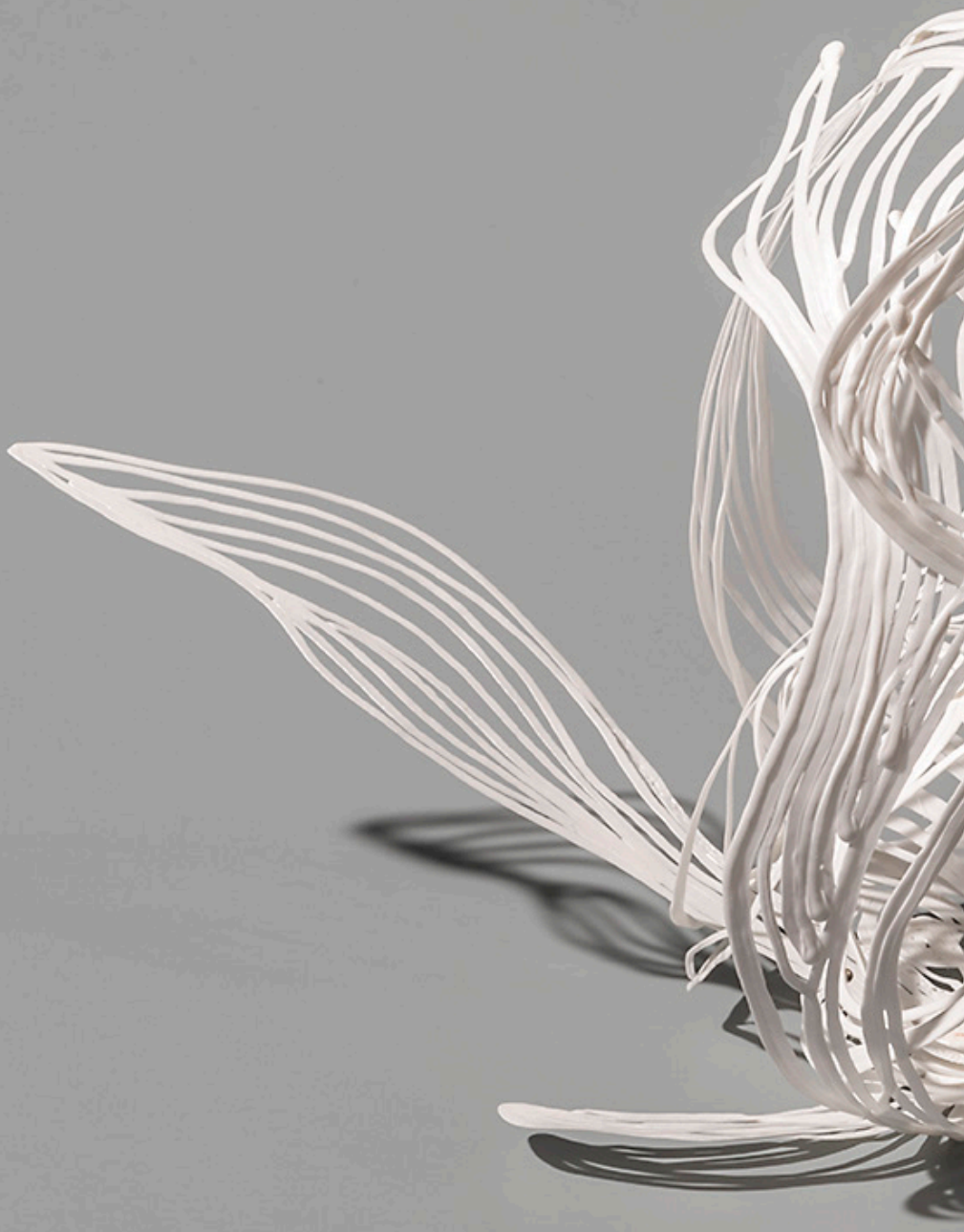
Thanks to our readers who completed the reader survey, especially those who took the time to write comments. Reader feedback helps us identify the material that you are interested in and improve the quality of *Zygote Quarterly*. Please continue to share your impressions, positive or negative. ×

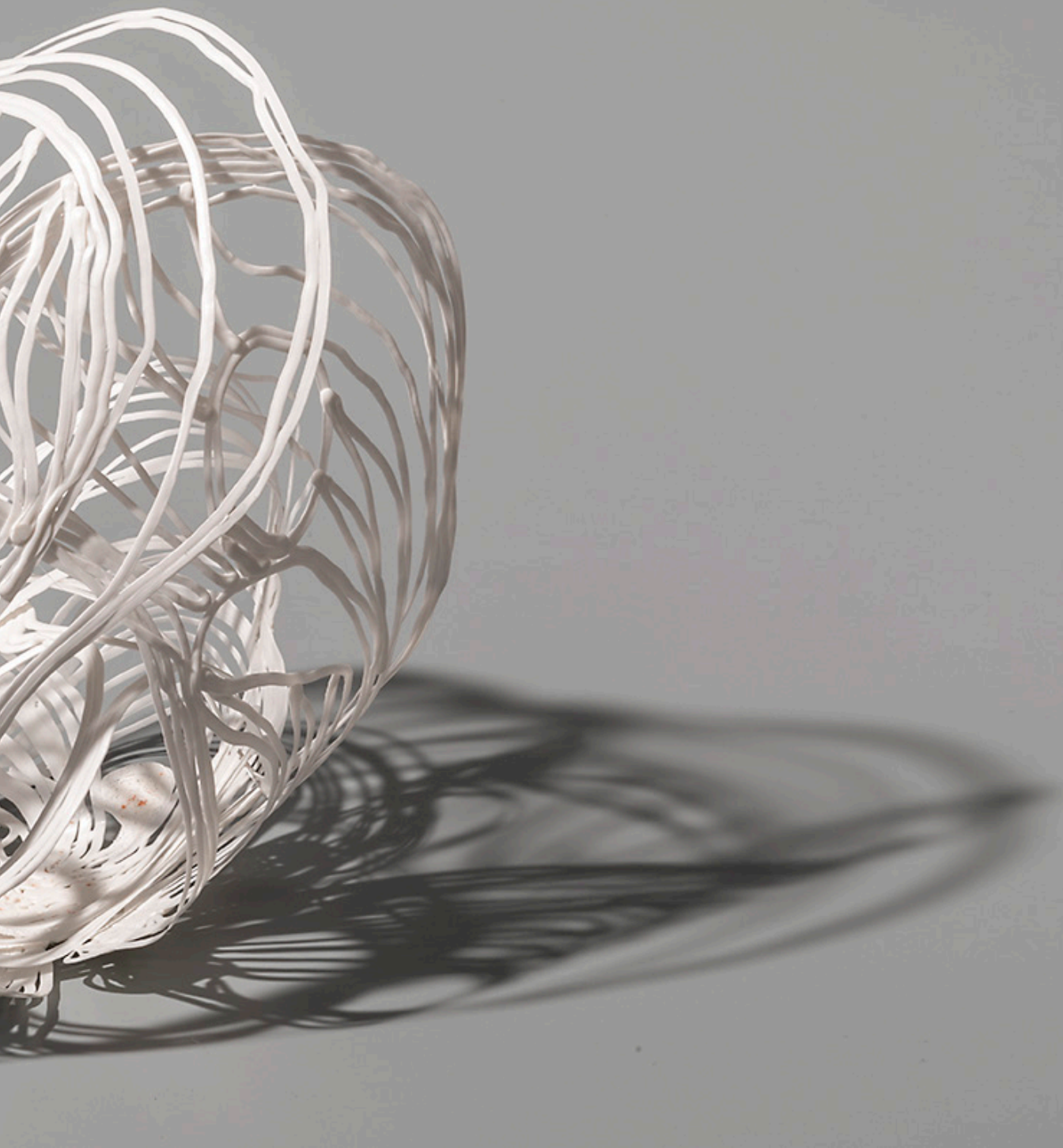
We would appreciate your feedback on this article: 

Type/Theme	Count of Articles	Average of "Yes" Ratings	Average of "Maybe" Ratings	Average of "No" Ratings	Average number of Comments
Case Study	4	11.3	0.0	0.3	2.8
Science of Seeing	3	6.7	0.0	0.0	1.7
Portfolio	6	5.5	0.0	0.0	1.0
Report	2	4.0	0.0	0.0	0.5
Stories from the Trenches	5	3.8	0.0	0.0	1.4
Article	1	3.0	1.0	0.0	1.0
Book Review	2	1.5	0.0	0.0	0.0
Interview	2	0.0	9.9	0.0	0.0



ZQ readership worldwide
Graphic: Issuu statistics





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