Work

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STEPHANIE VETO/LEHIGH UNIVERSITY ART GALLERIES

***Coral Forest*, made from yarn by Christine and Margaret Wertheim and the Institute for Figuring in Los Angeles, California, illustrates the effect of climate change on corals.**

ART GRAFT: PUTTING AN 'A' INTO 'STEMM'

Engaging in a creative pursuit can stimulate bold ideas, sharpen your focus and foster patience and perseverance in your research. **By Amber Dance**

Jeanette McLeod hid her interest in handicrafts for a long time. As a mathematician, she was sometimes the only woman in the room, and she didn't want to be seen doing something that could be interpreted as frivolous or frilly.

Then, in 2014, one of her colleagues at the University of Canterbury in New Zealand became pregnant. Along with another of the department's rare female mathematicians, McLeod hatched a plan to produce a crocheted baby blanket. Rather than doing all the hooking themselves, they recruited the entire department — mostly men who had not crocheted before — to contribute individual squares. McLeod schooled her colleagues in crochet at lunch breaks and in the pub after work.

Her students were enthusiastic. "We ended up with 60 squares for this blanket," recalls McLeod. "It was huge." Her secret was out and, by 2016, McLeod was well known in her department as a crafting mathematician; she enjoys sewing, knitting and crocheting, in addition to studying graph theory. That year, she founded the non-profit Maths Craft New Zealand to bring the joys of Möbius strips, hyperbolic surfaces and other concepts to the public through textile and paper crafts.

It's an idea that's catching on: in 2018, the US National Academies of Sciences, Engineering, and Medicine recommended that education in these subjects include the humanities, arts, crafts and design. In effect, the acronym STEMM (denoting science, technology, engineering, maths and medicine) is gaining an A for arts, making it STEAMM.

But the benefits of integrating arts into the scientific enterprise go beyond the classroom and into academic careers. Although some researchers might just be interested in science, others pursue varied interests such as crafts, theatre, languages and music. Those in the latter category say that, rather than detracting from the science, these avocations help to build skills that translate into their day jobs. Sometimes, they say, the arts directly inspire scientific questions. At other times, broader hobbies provide an opportunity to practise

skills such as creativity, perseverance and dexterity. That's not to say that scientists should adopt some artistic hobby solely for the sake of those benefits, but researchers who like to crochet, write poetry or play jazz shouldn't have to hide the time spent on those pursuits.

Research by Robert Root-Bernstein, a biologist at Michigan State University in East Lansing, backs up the concept. He's found that the most successful scientists are more likely than others to have artistic or musical hobbies[1]. Compared with other researchers, proportionally more Nobel prizewinners and members of the US National Academies pursued interests such as arts, theatre, or creative writing[2]. And STEMM graduates of the Honors College at Michigan State University were more likely to have licensed patents and founded companies if they also enjoyed arts or crafts[3].

Many such researchers tell Root-Bernstein that their hobbies directly affect their STEMM work. When they hit a wall in their day jobs, turning to something else can help them to relax, and suddenly a solution appears. "It's a strategy for coming up with ideas," he says.

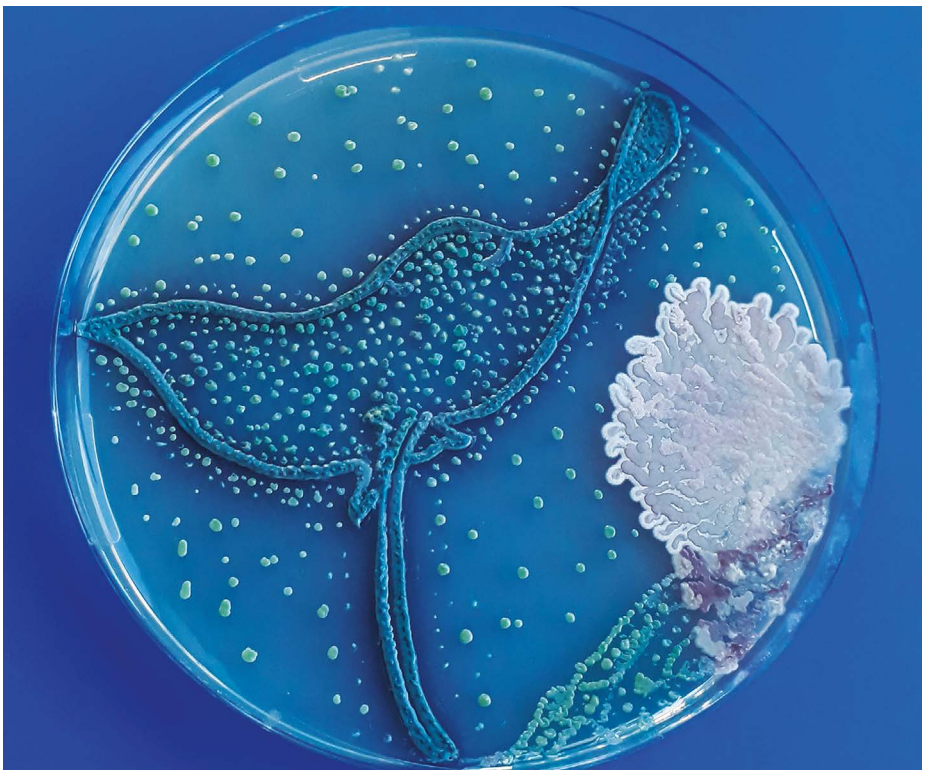
Creative endeavours

Root-Bernstein says that during his upbringing, no one raised distinctions between arts and sciences: his mother is a psychologist and artist, and his father was a computer programmer and sculptor. So, he was in for a shock in 1975 when he embarked on a PhD in the history of science at Princeton University in New Jersey. As he recalls, the university president told incoming graduate students: "You must put on blinders and do nothing but one thing for the rest of your life."

Researching his thesis on the origins of physical chemistry, Root-Bernstein found that many successful scientists had not taken that approach. The pioneering chemist and microbiologist Louis Pasteur, for instance, studied drawing when he was young, and kept an interest in the arts throughout his scientific career. It's been suggested that his artistic eye helped him to discover the chirality of molecules[4].

After his PhD, Root-Bernstein trained in biology, but he never abandoned his background in history. As a scientist, he always goes back to the very first paper published on a topic. He sometimes finds valuable information that's missed by those who limit their literature searches to recent years.

For example, when neuroscientists began to hunt for opioid receptors in the brain, they had a terrible time because opioids have so many binding sites. Eventually, scientists succeeded in identifying the receptors, and the field moved on. But Root-Bernstein wondered why opioids attached to so many parts of the brain. That line of inquiry led him to discover cross-reactivity between opioids, epinephrine and related compounds, and their receptors[5].



ISABEL ARAQUE AND JENNY ONATE/ASM

***Micro-Nature in a Spotted Eagle Ray*, created by painting a mixture of yeasts on agar.**

Alex McBratney, a soil scientist at the University of Sydney, Australia, also finds that his humanities interests feed his research, on occasion. He discovered poetry long before he discovered science; his most prized possession is a certificate that he earned for reciting poetry in primary school.

In a poem called 'Engines of Resolution', McBratney considered the nature of space and time, writing that "cunning engines must be constructed" to understand the concept. Later, the poem inspired him to study how soil varies over different spatial scales.

"Good science is a creative process," McBratney says. "I don't see it as being a fundamentally different creative process from writing a great poem or a novel, or [creating] a piece of art."

Courage to fail

Bravery, too, can be honed in the arts, says Stephon Alexander, a cosmologist at Brown University in Providence, Rhode Island. He's been playing jazz saxophone since he was 11, moonlights in a jazz duo called God Particle and considered a career in music before deciding that science was more stable.

Improvisation is a key element of jazz, and if Alexander hits a wrong note, he has to recover quickly and keep playing. He says that this principle works in science, too. "In doing theoretical physics research, my practice and my performance in improvisation allow me to take bigger risks with ideas, and not be too attached to the outcomes."

For example, while a postdoc at the SLAC National Accelerator Laboratory in Menlo Park, California, he spent weeks trying to visualize the rapidly expanding Universe. "I ended up having the wrong picture," says Alexander, "but that wrong picture led to a different direction." Following the new path, he developed a model to explain why the Universe contains more matter than it does antimatter[6].

Biophysicist Andrew Pelling isn't afraid of bold ideas, either. His early education in the arts included singing and dancing in front of an audience. "You develop a thick skin from that," Pelling says. So, at the University of Ottawa, he pursues the research questions he's interested in, no matter what others think. His group includes artists and designers alongside scientists and engineers.

The team once decided to use apple flesh, with the plant cells removed, as a scaffold on which to grow mammalian cells. "I cannot tell you how much vitriol and hate we experienced for doing something this non-traditional," recalls Pelling. But he didn't care — and the experiments worked[7]. Now, he says, other labs have replicated the technique and are pursuing it, too.

He has co-founded a company called Spiderwort (named after a common plant in apple orchards), to develop tissues on plant-based scaffolds. The company is starting early-stage trials, hoping to repair injuries to human soft tissues and the spinal cord.

Sometimes, a researcher's arts directly influence their science. Bernard Tan at the National University of Singapore started out as a semiconductor physicist. But he'd loved

music since childhood, had studied the piano and sung in choirs, and eventually taught himself to compose. As his career progressed, he gradually changed his science to match his hobby, studying acoustics and sound synthesis. "Music," Tan notes, "is the most mathematical of the arts."

Other benefits of musical training are less direct, says social psychologist Chia-Jung Tsay at University College London, who studied the piano in a pre-university programme at the Juilliard School, a conservatoire in New York City. The hours of practice required to reach a high standard accustom the brain to hard work and patience. Musicians are "very used to delayed gratification", says Tsay, noting that such an outlook fits a scientific career in which publications and promotions come slowly.

Another benefit of practising and performing music is that it hones the ability to focus, says Elaine Bearer, a neuroscientist at the University of New Mexico in Albuquerque who is also an accomplished composer. "When you're doing music, you're doing that one thing, and you do it with your full brain," says Bearer, who plays several instruments. "And when you do science that way, you do it really well."

Good hands

Music and crafts also provide the opportunity to work with one's hands. "You think differently when you're doing it, as opposed to when you're reading about it or writing about it," says Zoe Laughlin, a director of the Institute of Making, a cross-disciplinary club at University College London.

Crafting can also lead to a different understanding of objects. When Laughlin began a PhD in materials, after training in art, design and textiles, she found that unlike some of her classmates, she understood materials intuitively. She knew, for example – even if she lacked the vocabulary and equations to describe the process as an engineer would – that metals cast too quickly would crack. Plus, she already had the skills to work with various materials. While teaching undergraduates, she found that although many had high test scores, few knew how to use a hammer as she did.

During her PhD, Laughlin went on to craft cubes out of different materials, creating an art exhibit as well as a 'library' in which students can examine the properties of these materials. She also investigated how different metals influence the sounds of tuning forks and the tastes of spoons. "No one had looked at the science of what metals tasted like before," says Laughlin. Copper and zinc were bitter, for example, whereas gold was nearly tasteless, and these factors influenced the flavours of foods eaten with those utensils. "I have never tasted anything quite like mango sorbet with a gold spoon," she says.

"I don't see science as being a fundamentally different creative process from writing a great poem or a novel."

Science-based art can also be used to get a message across. In Los Angeles, California, science educator and writer Margaret Wertheim, who studied physics and maths, co-founded the Institute for Figuring, a non-profit body that examines the aesthetic dimensions of science, maths and engineering. Its projects include Crochet Coral Reef (see go.nature.com/cr-coral), which aims to communicate the effect of climate change on corals and to illustrate hyperbolic space in biology.

Alan Spivey, a synthetic organic chemist at Imperial College London, notes that the students who excel at tests aren't always the most skilful in the lab. Working with one's hands is crucial to most experiments. Yet different scientists following the same protocol can get different results, contributing to science's reproducibility problem, says Roger Kneebone, who is also at Imperial. A physician and amateur harpsichordist, he fuses his interests there as director of both the Centre for Engagement and Simulation Science and the Centre for Performance Science.

Could experience with crafts and the like help train scientists to perform lab tasks more effectively? Kneebone and Spivey teamed up with chef Jozef Youssef to design an introductory lab for chemistry students – in the kitchen. Before they ever mix acids and bases, the students at Imperial make cheese; a soft chèvre is popular. They learn precision by poaching eggs, where a half-degree difference in temperature will change the results.

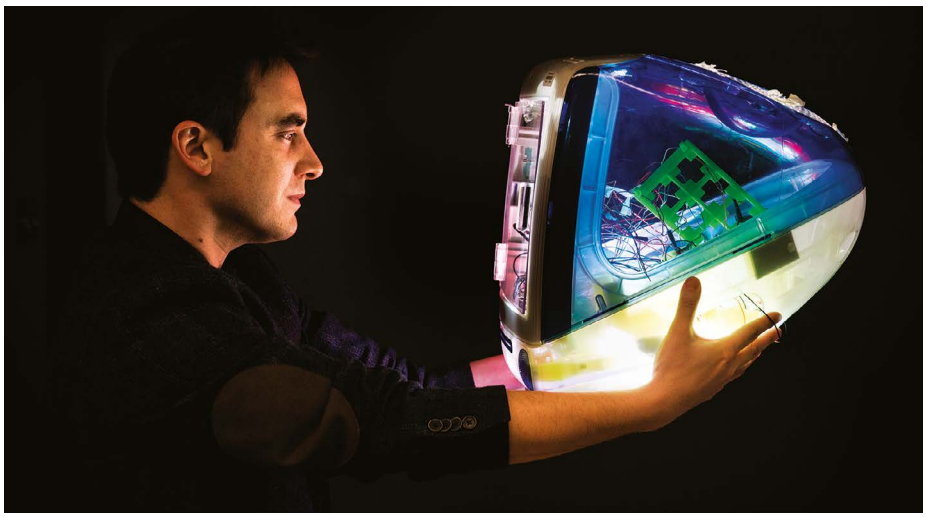
The course began in late 2019, and early surveys indicate that graduates of the cookery course are indeed more confident in their skills, says Spivey.

It might seem that pure maths requires little more than deep thought and a chalkboard, but McLeod finds that crafts provide an unintimidating entry point. Maths Craft of New Zealand's first big event was a two-day festival at the Auckland Museum in 2016. It drew more than 1,800 visitors – the biggest crowd that the museum had ever hosted, says McLeod, and a record that Maths Craft broke a year later, when its festival attracted 3,400 people.

At the festivals, families work together to create origami polyhedrons. Or they experiment with paper Möbius strips, or crochet ruffled hyperbolic planes. Sooner or later, someone notices that there are no equations. That's just McLeod's point: "Maths is accessible, and anybody can do it."

In her own research, McLeod has begun to unite design and maths, investigating the mathematical properties of the Greek key design common on Mediterranean pottery. Remarkably, she says, there are only seven ways to put that kind of pattern together.

And now that her long-hidden love of crafting is out, an origami video from Maths Craft graces the research web page of the University of Canterbury School of Mathematics and Statistics. McLeod's secret, far from diminishing her scientific reputation, has only enhanced it.



COLIN ROWE

Biophysicist Andrew Pelling repurposes old lab gear to make quick and creative prototypes.

Amber Dance is a freelance writer in Los Angeles, California.

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Correction

The caption accompanying the image of the *Coral Forest* yarn sculpture in this Career Feature neglected to name the artists. The sculpture was made by Christine and Margaret Wertheim and the Institute for Figuring.