Thin but tough. You's origami-inspired inventions include a flat-folding bag made of rigid steel.

PROFILE: ZHONG YOU

'Origami Engineer' Flexes to Create Stronger, More Agile Materials

A latecomer to the Japanese art of paper folding helps harness the mathematics behind it to make medical devices, disaster shelters, and, possibly, rockets

Zhong You never cared for origami. As a child growing up in Shanghai, China, in the 1960s, he considered the ancient Japanese art of paper folding pointless at best. "It was all about how to fold a frog or something else that was pretty but had no use," he says. "Also, I was no good at it!" It took several years and a handful of insights before You—by then a civil engineer working in a distant country—would find himself using the folding techniques that irked him in his youth to design medical instruments, emergency housing, and even space rockets.

You, now based at the University of Oxford in the United Kingdom, describes himself as an "origami engineer," one of a small number of researchers who build a variety of objects from folded sheets of rigid material. The discipline first gained prominence in the 1970s, when engineers realized that they could pack solar panels that had been etched with an origami crease pattern into a small volume for transport in shuttles and quickly and easily unfold them in space. But since then, You feels that its potential for transforming a host of structures across a range of scientific disciplines has been largely ignored—and that's something he hopes to rectify.

At first glance, You's lab appears messy, littered with crumpled paper, grocery bags, and cans. But on closer inspection, the folded sheets are prototypes of foldable building parts, while the old bags and cans have been carefully collected because of their shape. A can picked up in Tokyo, which once held a vodka and lemon drink, caught You's eye because its surface carries a crease pattern of tessellated diamonds. "The drink is nasty," he says, "but the can made me think about what would happen if you put an origami pattern on a rocket." A compactly folded paper bag from a takeout in Boston, meanwhile, provides inspiration for squeezing down medical devices for easy transport inside the body.

Insider. Creased stent is designed to snap open inside an artery.

You had his first brush with origami engineering as a graduate student at the University of Cambridge in the 1990s. Before coming to England, he had worked in naval architecture at Shanghai University, using conventional foldable structures that bent at hinges and had moving parts that slid over to make objects more compact. But at Cambridge he met a fellow student, Simon Guest, who was using the solar-panel-folding trick to store kilometers of tubing for deployment on space flights, and realized that rigid origami could do more than help save room. "Hinges and sliding parts can stick, especially when you need to open and close structures many times," he says. "Rigid origami creases are much more reliable."

It took another decade, however, before You began to apply origami seriously. Engineers were reluctant to waste time groping for the best folding patterns through trial and error, he explains. At a mathematics conference on origami in Boston, however, You became aware of blossoming research into the geometry of folding and realized that it could provide rigorous blueprints for manufacturing.

With this mathematical underpinning, You turned his attention to tools for exploring inner rather than outer space, by redesigning the surgical stents, or artificial tubes, inserted into arteries to remove blockages and repair aneurysms. Standard stents are made of an expandable metal scaffold, covered with fabric, which is guided into position and then opened. But like a broken umbrella, the fabric can easily detach from its metal scaffold and fail to make full contact with the artery walls on opening. You's "origami stent," by contrast, is made of a single material, folded down so that it can pass through the arteries and then snap open once in position.

You plans to put the origami stent through animal trials early next year.

CREDITS: THE DEPARTMENT OF ENGINEERING SCIENCE, UNIVERSITY OF OXFORD

He also hopes to adapt it for use in the brain's delicate blood vessels, which require stents far more flexible than those normally used in other parts of the body. "The synergy with space applications is clear: An object has to be deployed in a hostile environment, and any error could lead to disaster," says Guest, who still works on foldable structures at Cambridge, independently from You.

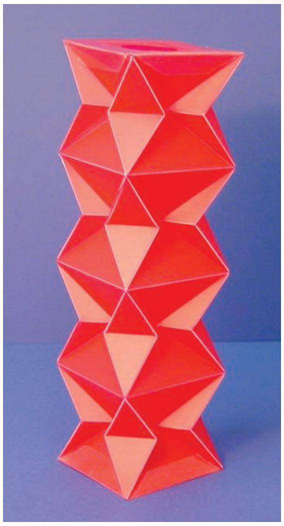
Erik Demaine, an expert on origami-based robotics at the Massachusetts Institute of Technology in Cambridge, calls You's origami stent "the most important current application of origami engineering." He notes that origami engineers have ambitious long-term goals: for instance, building houses that can be reconfigured at the push of a button, with entire rooms that can be folded away and change functionality. One of You's skills is to find useful near-term applications that build toward these futuristic dreams, he says.

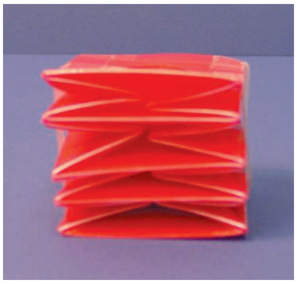
In particular, You and his doctoral student Joe Gattas are turning the vision of reconfigurable housing into the more easily achievable reality of emergency shelters that can be transported as flat sheets and unfolded in the aftermath of natural disasters, where there is little hope of bringing in complicated machinery. Gattas thought of the idea during the recent spate of flooding in his native Australia. "People who have lost their homes need something more solid and comfortable—more homelike—than a tent," he says.

Guest likes the concept but notes that in untrained hands, there's no such thing as a foolproof self-assembly kit. You acknowledges the concern with a smile: "It's true, the challenge is to keep things simple. Even the best engineers have difficulty putting together flat-packed furniture."

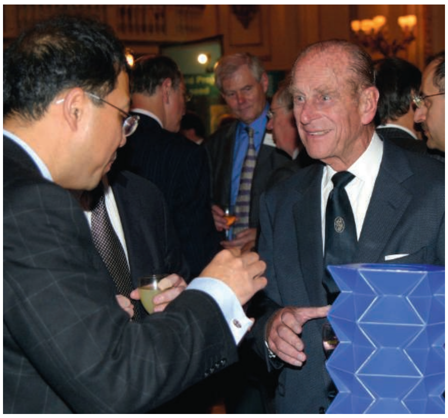
Fittingly, You also has his eyes on packing processes. He recently designed a grocery bag made of steel that can be collapsed down as flat as a paper bag. His prototype proves that any rigid package, including open-topped cardboard boxes, can be folded down if it has the right crease pattern; currently, both top and bottom need to be opened for flat packing. "The packaging industry is the one place people have traditionally thought deeply about paper-folding techniques, and this could really speed up factory assembly lines," he says.

Origami can do more than make things more portable, You adds. For example, take the patterned Japanese drink can that inspired him to investigate designs for a shuttle. "The manufacturers put the design there to make the can look pretty, but it makes me think about how a crease pattern can strengthen or weaken the can's ability to withstand the pressure from the carbonated drink inside," he says. "I realized we could turn the origami concept on its head and look for patterns that would make things hard to fold and crush."





Crush-resistant. Pleated columns inspired by a beverage can are strong but lightweight—a combination that may prove useful in silos, rocket bodies, and shock absorbers.



Royal nod. Prince Philip views You's work.

CREDITS (TOP TO BOTTOM): THE DEPARTMENT OF ENGINEERING SCIENCE, UNIVERSITY OF OXFORD (3); THE ROYAL SOCIETY

You has been thinking about plans for lighter-weight space rocket and silo bodies that use less material but remain strong, thanks to a crease pattern. But even if they pass muster, implementation of such large-scale designs would still be years away. Meanwhile, You is using the same principle to develop a more down-to-earth product: a more effective shock absorber for the Land Rover. In theory, he says, etching origami folds into the metallic cylinders behind car bumpers should increase the energy they absorb on impact by up to two-thirds. His group is in the process of testing the claim.

It has not all been plain sailing for You. The downside to working on a vast range of projects spanning many fields is that with each new invention, You must establish his reputation afresh and persuade a new group of people to replace standard manufacturing techniques with an origami-based alternative. "It can look like we are reinventing the wheel," he says. "We have to work hard to prove that origami has benefits."

Joseph O'Rourke, a mathematician and expert on the geometry of folding at Smith College in Northampton, Massachusetts, says people are still largely unaware of origami's merits for science. "This is a new area, with academic publishing just starting," he says. But he adds that the ideas are starting to disseminate as more mathematical books and conferences cover the topic.

In 2006, You's work also received a royal seal of approval when he was asked to show some of his devices at a science exhibition at Buckingham Palace. "The Duke of Edinburgh came over to me and asked what the function of each piece was. It was quite an honor," he says. The origami structures have also been a hit with the public at exhibitions. "People keep offering to buy my pieces as stress-relieving toys, and I have to say, 'No, they are prototypes,'" he laughs. "Still, at least I know that if engineering doesn't work out for me, I can set up a business as a toymaker."

For now, however, You remains one of a niche group of researchers "exploring uncharted waters" in design and invention. But that's okay by him. "We're in the position where so much remains to be done," he says. "Every day, there's huge potential for an important discovery."

–ZEEYA MERALI

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