Curved-crease origami sculptures can self-fold into intricate patterns.

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Q&A Erik Demaine

The origami geometer

Computer scientist Erik Demaine uses origami to advance computational geometry and create art. His paper sculptures, made with his father, artist Martin Demaine, are now on show at the Japanese American National Museum in Los Angeles, California; from August, the exhibition will tour the United States. He explains the challenges of folding together mathematics and art.

NICK HIGGINS

Folding Paper: The Infinite Possibilities of Origami
Japanese American National Museum, Los Angeles, California. March–August 2012.

How did you come to do most of your work with your father?
When I was five, I helped him to design wire puzzles for toy shops across Canada. He educated me himself as we travelled around the United States. When I went to university at the age of 12, he attended all my classes, mostly computer science and mathematics. Eventually, we started working together on mathematics and art. He is now an artist in residence at the Massachusetts Institute of Technology (MIT) in Cambridge, where I am a computer scientist.

How did you discover origami?
I heard about Robert Lang, a great origami designer and physicist. Computational origami was just starting, and my father and I became pioneers. Our first project was the fold-and-cut problem: how many shapes can be made by folding a sheet of paper, making one straight cut, then unfolding it? Houdini made a five-pointed star in this way in the 1920s. It took us years to prove that you can make any straight-edged shape; we have designed swans, butterflies and the MIT logo. Another result was an algorithm for folding any three-dimensional (3D) shape out of one sheet of paper.

What is 'self-folding' origami?
It is a form in which the force of the creases pulls the material naturally into shape, without any manipulation. We're trying to find an algorithm to make any 3D shape with this method. One application would be a space station that assembled itself in space. We have devised a grid-based crease pattern that would allow a microscopic sheet to self-fold into any shape, in theory, by making cubes that stack together like 3D pixels. We haven't yet achieved self-folding at the nanoscale.

What kind of origami are you doing now?
We have been working with curved creases, the properties of which are poorly understood. We were trying out some curved patterns, and saw that they looked beautiful. We're still pursuing unsolved mathematical problems too. David Huffman, who invented the compression algorithms used for mobile phones, left many beautiful origami sculptures when he died in 1999. He was getting to the point at which he could conceive a 3D form, then reverse engineer the steps to fold it with curved creases. We hope to have him as a posthumous co-author on some papers.

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How do you actually fold the paper?
For prototype models we use a robotically controlled laser to score the paper, but we prefer a simple compass-like device. The final folding we always do by hand. At the first show we contributed to, we made three sculptures by folding two circular pieces of paper together using alternating pleats in concentric circles. Curved-crease sculptures go back to a late-1920s design by the Bauhaus school in Germany. The surprising thing is how they self-fold into ornate forms from these simple creases. For the *Folding Paper* exhibition, spanning the range of origami art, we gave ourselves a little more power by manually joining a few key points together.

How did you come to study balloon animals?
That was a collaboration with my father and Vi Hart, a composer whose own father is a mathematical sculptor. We noticed that balloon animals could be seen as outlining the edges of a flat-sided 3D solid, and we found an algorithm that tells you how many balloons you need to build a given solid. One application, conceived after the fact, would be to build a pavilion from a single tube. But our motivation was just to play with balloons. ■

INTERVIEW BY JASCHA HOFFMAN