

FOREWORD

For hundreds of years, the art of folding paper—origami, to use its Japanese name—served two purposes, both aesthetic: entertaining craft and symbolic decoration. In the middle of the twentieth century, though, the practice underwent an artistic renaissance as artists and craftspeople developed new and innovative methods of designing and folding their intended forms. But it also underwent another change: origami came into the world of science and engineering, and both fields have been immeasurably enriched by the meeting.

At first blush, this would seem to be an odd pairing: an ancient Japanese art and the modern, science-driven world of engineering. What could these two practices possibly have in common? What engineering and paper folding share is that both are bound by laws that specify what you can and cannot accomplish, and those laws are effectively described by the language of mathematics. Mathematics is a purely abstract logical system, and yet it has remarkable power in the physical world: it tells cosmologists how the stars and planets dance and tells engineers whether a beam has the strength to support its load. It can also tell an origami artist how much paper to allocate for each feature of the subject, and even the arrangement and number of folds. When mathematical methods came to origami, the art form changed in ways that were unprecedented, resulting in artworks undreamed of by the artisans of old.

An origami artist is usually motivated by aesthetic goals; an engineer by functional requirements. But sometimes—even often—both sets of goals may be satisfied by the physical phenomenon of folding. And when that happens, the tools of artistic origami and the underlying mathematics of the same can be pressed into service to address the needs of the engineer. The folds of origami can create a wide variety of shapes and, as well, a wide range of mechanisms. The mechanical repertoire of origami includes levers, pivots, hinges, force multipliers, distance reducers, conversion

of direction of motion, and more. When we combine that versatility with the simplicity and ubiquity of a planar sheet starting material, the match between origami and engineering begins to seem almost natural.

And, amazingly, the same logical system underlies both art and technology. The mathematics that describes origami is agnostic about the application to which it is put. Whether one is creating a bird, insect, or flower, or a solar array, backpack, or furniture, the same principles are at work; the same patterns apply; the same equations describe. We can apply folding to both artistic and technological ends. Because of this duality we find the practitioners of origami moving readily between artistic and technological fields, applying their skills to both, separately and together.

Scientists and engineers often emphasize the formality and rigor of their craft, and with good reason; it is by following the rigor and logic of mathematics and the cumulative growth of knowledge that comes from following the scientific process and the engineering discipline that has led to advances in the human condition. But the dirty little secret of all of the hard scientific fields is that even the most rigorous science, the most formal mathematics, is partly an art. Qualities like elegance and beauty are part and parcel of the scientific endeavor. The wonder of origami is that any given form might find its home in either camp. Is it art? Is it science? Does it matter? Whether used for aesthetics, functionality, or a combination of the two, origami has much to give—and in this book, you will see many examples of both, sometimes emphasizing one, sometimes the other, and sometimes in equal measure.

Robert J. Lang

INTRODUCTION

This book grew out of an exhibit at the Brigham Young University Museum of Art in 2015 that featured origami art from around the world and demonstrated the connections between art, engineering, design, science, and mathematics. The exhibit, “Folding Paper: The Infinite Possibilities of Origami,” was also supplemented with designs developed at BYU, where we have conducted research based on the hypothesis that products and engineering systems could be designed to achieve the motions found in origami, with similar levels of efficiency, but using different materials and processes that would enable them to meet emerging product needs. Because origami models start from a flat sheet, they can be made using inexpensive high-production methods; they can be very compact; and they can be made of one piece of material. The results of our research, which were graciously funded by the National Science Foundation, the Air Force Office of Scientific Research, and NASA, among others, have been published in academic journals and conference proceedings because they are mostly theoretical. However, as evidenced by the many examples in this book, our research in origami design and in the mathematical and engineering possibilities latent in the simple act of folding has the potential for immediate and wide-reaching impact.

Who would have thought that the beautiful and ancient art of origami would be a catalyst for new discoveries in science, engineering, design, and mathematics? But origami represents the ultimate efficiency in creating sophisticated motions. Constructed from a single, regular-shaped sheet of paper, it uses only one fabrication process: folding. For centuries artists have invested immeasurable effort developing origami models within these constraints. Because paper is an accessible and formable medium, prototyping vast numbers of possible designs is relatively efficient and effective, resulting in stunning motions in a simple medium that were not previously conceivable using other methods.

To learn to fold may be considered a kindergarten rite of passage, but folding is also a powerful and versatile practice used to build our world. Do you remember when you were first learning to fold? Trying to match up the corners of the paper and make a straight crease, or trying to fold a sheet into a neat square? The rudimentary skills you mastered to correctly fold probably went uncelebrated. However, even as your folding proficiency increased, these fundamental skills also served as the basis for other physical and cognitive abilities you developed. Today, while it has possibly been ages since you refolded a paper map, you understand something about exactness, or how materials behave, or even about operation sequencing because of folding.

This book demonstrates the potential of folding to improve the way things function, to simplify how products are made, and to create new objects that would otherwise be impossible to create. We have organized the example section to display the product prototype next to the work of origami that inspired it. The solar collector, the felt stool, and the surgery tool were all influenced in some way by folding paper. We've tried to include models made from a range of materials and in a range of sizes. This includes everything from a microscopic machine to huge solar panels designed to unfold in outer space. Most of the models are in the prototype phase—meaning that physical hardware has been built to demonstrate the concept, but the models are not necessarily available commercially. This book includes most of the technologies and products featured in the exhibit “Folding Paper: The Infinite Possibilities of Origami,” and it also expands into other areas that have not been publicly displayed.

The book's title, *Y Origami?*, was chosen for its double meaning. It addresses the question of “why origami?” or “are there practical uses of origami?”, and it also illustrates an answer to that question by showing research that has been done at Brigham Young University, or “The Y.”

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