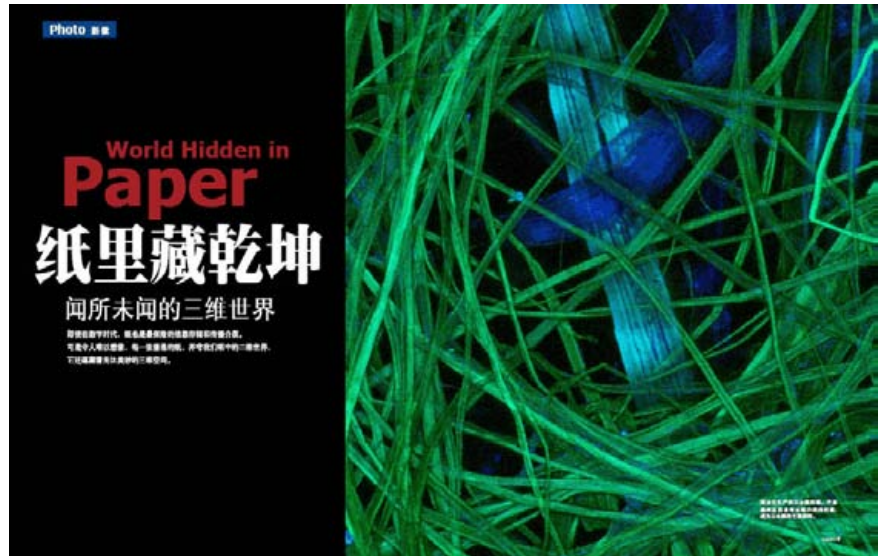


World Hidden in Paper

The 3-D World That Has Never Been Seen Before

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Even in the digital age, paper is the safest material for preserving images and text. Unexpectedly each sheet of common "flat" paper also has a wonderful 3-D world hidden within it.



Commercially made Japanese paper fibers (S&T). Many of these papers use mulberry tree bark for the main paper fiber since it contains long and strong fibers.

In front of a microscope deep in the sub-basement of the life sciences building at Arizona State University, I took a common and seemingly uninspiring material and sat down for a look. Instead of the dull experience I expected, under the light this material took on an otherworldly range of colors and structures. And what started as a simple scientific question began my journey into one of the today's most fascinating and likely the most ignored man-made materials, paper.

When my colleague Gene Valentine came to me in the summer of 1998, he had one simple question. Could I look at some paper he was making from silk fibers using one of the microscopes in my laboratory? The Paper Project was born that day and our exploration of handmade papers began.

Just what is Paper? While the root of the western word for paper is papyrus. Papyrus is not paper. To be considered paper a material must fit within the modern definition set by Dard Hunter who is considered the father of contemporary papermaking. Dard Hunter defined paper in the following way.

"To be classed as true paper the thin sheets must be made from fibre that has been macerated until each individual filament is a separate unit; the fibres intermixed with water, and by the use of a sieve-like screen, the fibres lifted from the water in the form of a thin stratum, the water draining through the small

openings of the screen, leaving a sheet of matted fibre upon the screen's surface. This thin layer of intertwined fibre is paper."

The primary tool for our study is the scanning-laser confocal microscope. This type of microscopy is unsurpassed for producing sharp three-dimensional (3-D) images. Under the laser lights, the images that emerge from our paper samples also reveal a remarkable range of colors, which are not at all what you'd see in sunlight (reflective light). Instead they are rich in bright, florescent colors. Most biological materials have a natural fluorescence. Paper's colors are the direct result of the structure of the cellulose and protein materials and how they are intermingled and woven together, and not from a dye or another color additive. In fact, the resulting images we've collected have proved to be helpful in understanding how the fibers are interlaced within a specific paper, besides being esthetically interesting works of art.

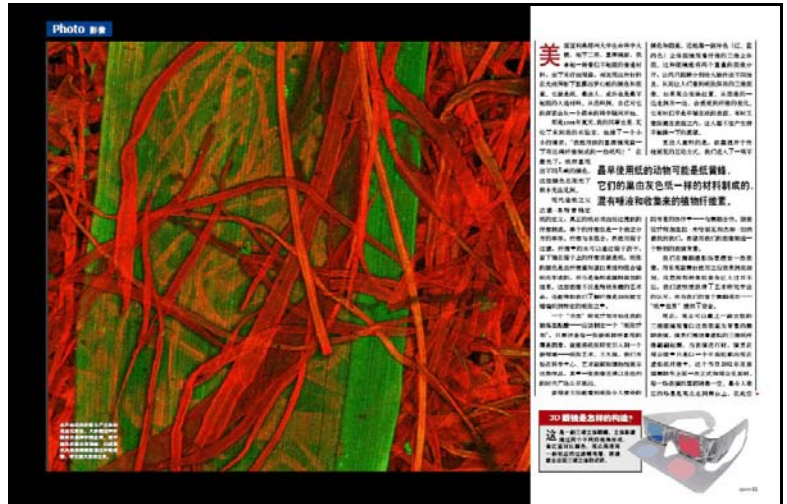
The beautiful images that emerge from the examination of each new sample of paper are what propelled the Paper Project into new areas and disciplines - areas not usually included in a scientific study: photographic and canvas art, dance and choreography. Visitors to the exhibits not only saw the wonderful range of color and structure in paper; they were able to see the 3-D structure of the fibers by wearing a pair of anaglyphic (red-blue) glasses. These

simple glasses separate two overlaid images so each eye can send the necessary information to the brain where the final image is constructed. Under normal circumstances, each eye "sees" a slightly different view (angle). It is the difference in angle that gives each person their ability to see depth or what we call 3-D. Using this technique people can now explore paper as if they themselves had shrunk down to the size of a period at the end of a sentence and stepped into it. Where literally a person sees what lies beneath the surface.

The interactive nature of these more traditional exhibits, ultimately led us into one of the most unusual collaborations for the Paper Project - dance. Through an unexpected chain of events, two costume designers, Galina Mihaleva, and Jacqueline Benard, who had seen some of the art images along with dance choreographer, Jennifer Tsukayama, approached us with a desire to create a performance piece using them. None of them had seen our lectures or experienced how fantastic the 3-D images could look when enlarged to the size of a theater screen. So we set up a viewing in one of the dance studios and showed them how the depth in the images only got deeper as the images were projected larger. Once they had a chance to view the images at that large of a scale, the Paper Project took a step in yet another direction. Within a year we obtained a grant from the Institute for the Studies in the Arts where that funded our first dance project called Paper Interiors.

Now imagine, sitting with an audience where every-one is wearing those funny red-blue 3-D glasses. On the stage are dancers that are performing, moving in and around virtual 3-D paper fibers. Then add to the real dancers that have volume and dimension some flat 2-D shadows of dancers. As the performance develops the real dancers also become silhouetted and flat and join the shadow dancers in the virtual paper fibers. All this is made possible with five computer projectors and a lot of lighting magic. The results are a dance performance where the idea of what is flat (2-D) and what has volume (3-D) becomes blurred. To add to the experience, as the dancers and fabrics move within the space, the virtual space takes on an almost liquid appearance.

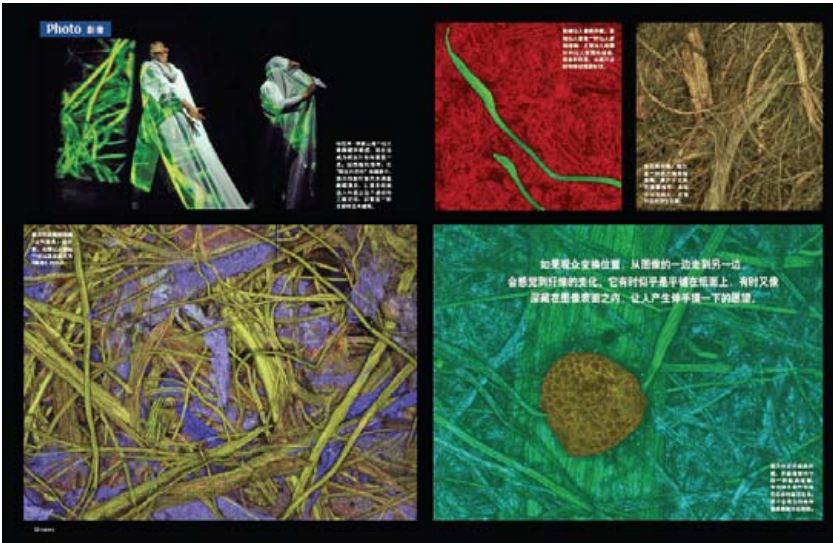
Paper wasps are likely the earliest animals making use of paper. These wasps make their nests using paper-like techniques, their saliva, and plant fibers.



Commercial made paper of unknown fibers. Most likely the fibers are from the mulberry and gampi trees. Using the scanning-laser microscope the translucent qualities of paper fibers is revealed. The funny looking red and blue glasses are used to look at specially made images in 3-D.

Our dance exploration was just a start in 3-D immersive experiences based on the Paper Project images. The performance debuted at the American Dance Festive in 2002. Every show was sold out. We had Jennifer join the Paper Project creative team soon after the performances ended. The only thing missing was a way for the audience to actually walk onto the stage and experience the space themselves. This got us thinking about another dimension to add to the paper experience: we proceeded to create a 3-D immersive room that provides just that, a space where visitors can walk into and experience 3-D paper fibers for themselves. Once completed, we named it: Fiberscapes.

Fiberscapes is a room where 3-D images are projected on three walls and the floor. The images shown are action videos that include the mysterious shadow dancers first introduced in the dance performance. The shadow dancers appear to come out from paper fibers, as well as up from the floor. Visitors walk into the 3-D space and are immediately surrounded by light, color, music and the shadow dancers. The virtual dance is accompanied by a music sound track that provides a rhythmic beat and flowing melody driven by electronic instruments. The images and move within the space. The feeling is immersive as well as interactive. This is promoted in part by the projectors which are positioned in a way



(Upper left) Scene from Paper Interiors dance choreographed by the newest member of the Paper Project, professor Jennifer Tsukayama. Lighting is used to shift dancers into and out of the virtual 3-D space. (Top middle) Paper made from Barrel Cactus plant fibers. (Top right) Paper made from Yucca plant fibers. (Bottom left) paper made from Australian Fan Palm plant fibers. (Bottom right) paper made from Australian Artichoke Thistle plant fibers. The gold-brown round object is a pollen grain trapped during the paper making process.

that each visitor's own shadow projects into the room and become a part of the experience. Young children are given white fabric sheets to take into the room, so that they can dance and move within the space along with the virtual dancers. The sheet makes them almost invisible to other visitors and encourages a full, personal exploration of the 3-D environment.

The Paper Project is entering into its tenth year soon and with it will come more wonderful images and new ways of exploring how people can experience what lies beneath the surface of a common sheet paper. Just how many beautiful images go unnoticed each day? Considering the images you are looking at are from an area no larger than a period at the end of a sentence, even using conservative numbers, each paper contains about a thousand little pieces of art. If you think of the number of sheets of paper produced each day, there are literally trillions of beautiful images that we simply let slip between our fingers. How curious it is that it has taken modern technology to reveal the inner beauty of one of humankind's first technologies. Paper has served us well. It has been the keeper of our history and the conveyor of knowledge from generation to generation. We may be in the digital age, but paper is still king when it comes to archiving content and, from what we have discovered, it's also filled with a world of hidden beauty. With our web site

(paperproject.org) people from around the world can join us as we discover more about the uncommon side of this most common material.

About the author: Charles Kazilek is an artist and scientist. He is currently the Director of Technology Integration and Outreach for the School of Life Sciences at Arizona State University also the Technical Director of the W. M. Keck Bioimaging Laboratory where the images of paper were made.

Thank you to Chen Liu for the helping with the translation of this article.



Paper made from Australian Fan Palm plant fibers. With its rich blue and green colors, this image reminds people of the works of Claude Monet.