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ENVISIONING SCIENCE—A PERSONAL PERSPECTIVE

PORTRAIT: ALLAN M. BURCH

FELICE FRANKEL *is artist in residence and research scientist at the Massachusetts Institute of Technology. She is coauthor of* On the Surface of Things *(Chronicle Books). She is presently working on a handbook,* Envisioning Science, *on how to visually express scientific data, partially funded by the National Science Foundation.*

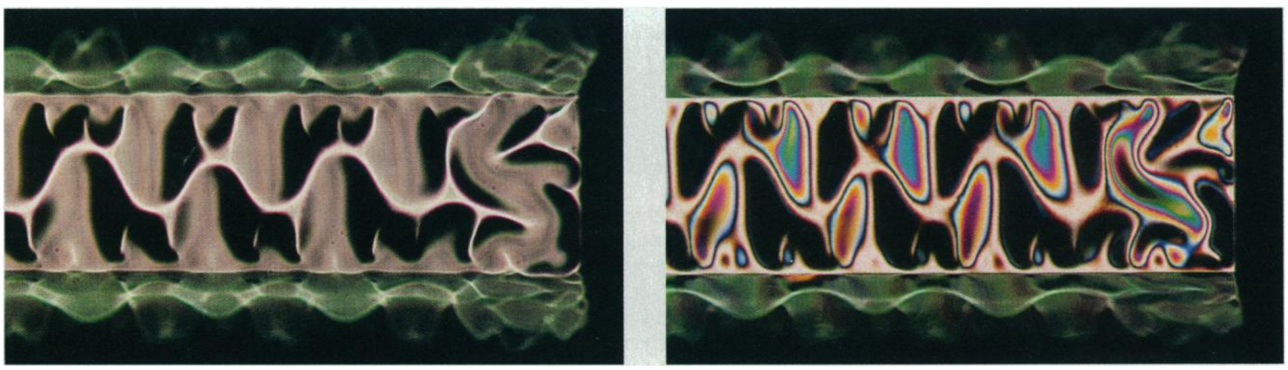
The images you see here are photographs of scientific research. However, their aesthetic qualities, being immediately apparent, often seem to dominate initial reactions to them. I, in fact, created them primarily to serve the scientific community, to record and communicate data, and to further the research. I have recently become aware that the visual impact itself of the photographs I make in the lab can have significant consequences, allowing them to communicate important information about science research not only to other scientists in the lab, or in the field, but to a broader, nonscientific public as well. So I have come to recognize and to embrace the two worlds my work inhabits, scientific and aesthetic. On the one hand, I bring to science photography my passionately curious, fresh, and aesthetic eye. And on the other hand, though I am not an optical or electron microscopist, I use their tools, but I use them with a different point of view: to locate the innate beauty of the research, and to capture it with the kind of technical accuracy that can add information and generate new ways of thinking.

Too often the visual beauty of science research seems to be kept secret. Scientists are trained to be suspicious of visually stunning displays, often dismissing them as unnecessary or superficial, and thus remain largely unaware of the value of the visual poetry of their own work. Their publishers and editors, even of the most prestigious journals, do not often underwrite color reproduction even when it might clarify the data, or when budget constraints do not play the deciding role. Meanwhile, the art departments of the same journals are also frustrated by too many submissions lacking technically refined and attractive images. Nor do funding agencies seem interested in the way science "looks," so it appears from their publications, although it is ever more important to communicate science to a broader public.

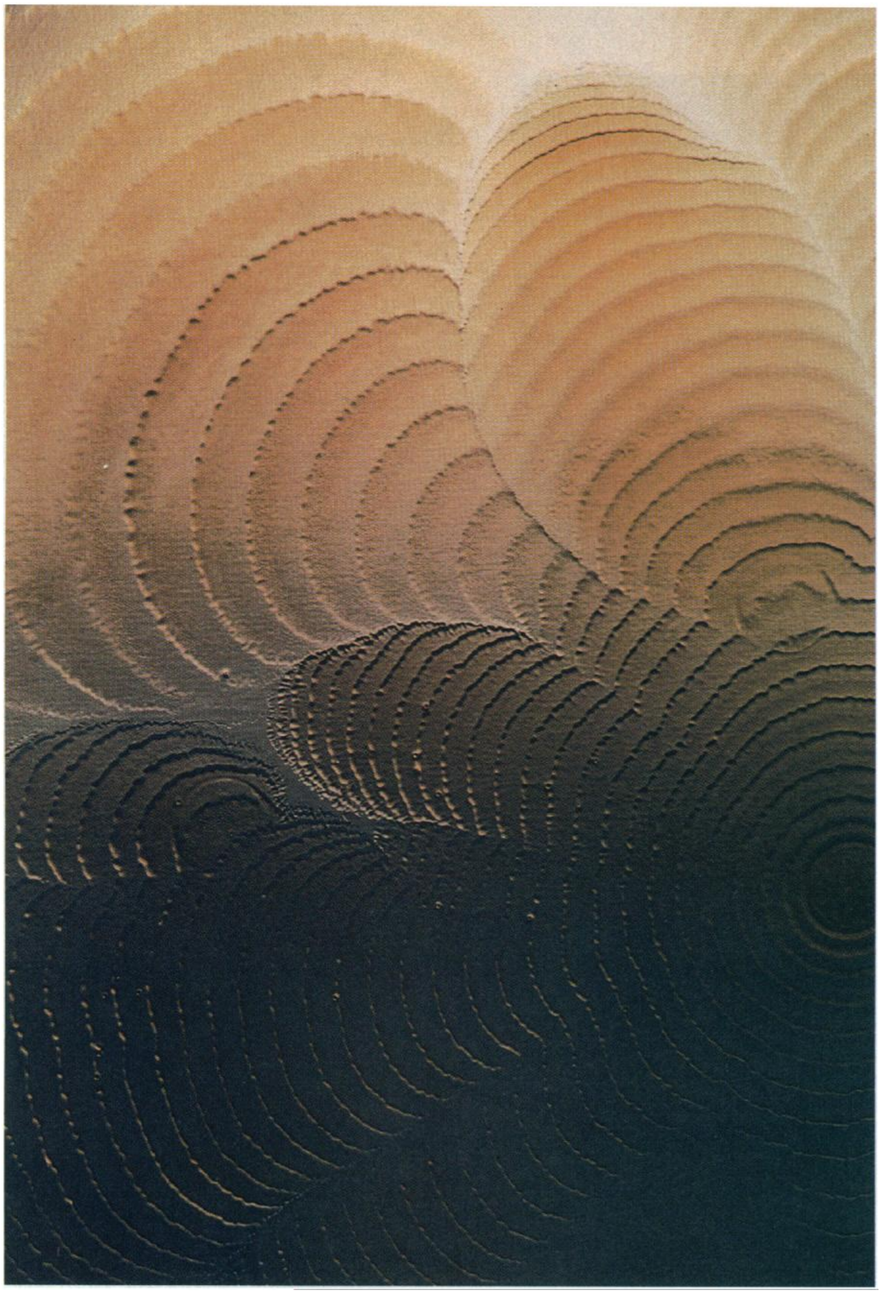
I believe that we who are privileged to see science's splendor, who image it, diagram it, model it, graph it, and compose its data, can turn the world around, dazzling it with what inspires and nourishes our thinking, if we refine the visual vocabulary we use to communicate our investigations and incorporate—beautifully and above all accurately—the visual component that is already there. Our goal must be to share the visual richness of our world, to make it accessible.

For me, form, shape, and composition are integral to a scientific image or representation; I compose data, making it readable and comprehensible, and the theorists and experimentalists with whom I work agree that visually clarified information adds another dimension to the exchange of ideas. They tend to be the investigators who are expanding their boundaries, sometimes into scientific disciplines of which they never dreamed. They are learning to use their equipment for visualizing the increasing complexity and dimensions of their work in new ways, with the same rigor in their imaging as in their scientific thinking; when what was once "good enough" is no longer good enough.

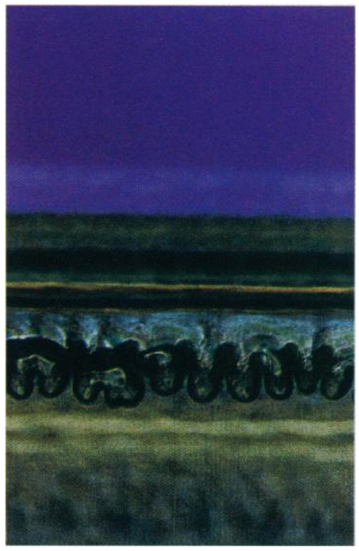
Although some of the images I take are displayed in art galleries and museums and are reproduced in books that re-



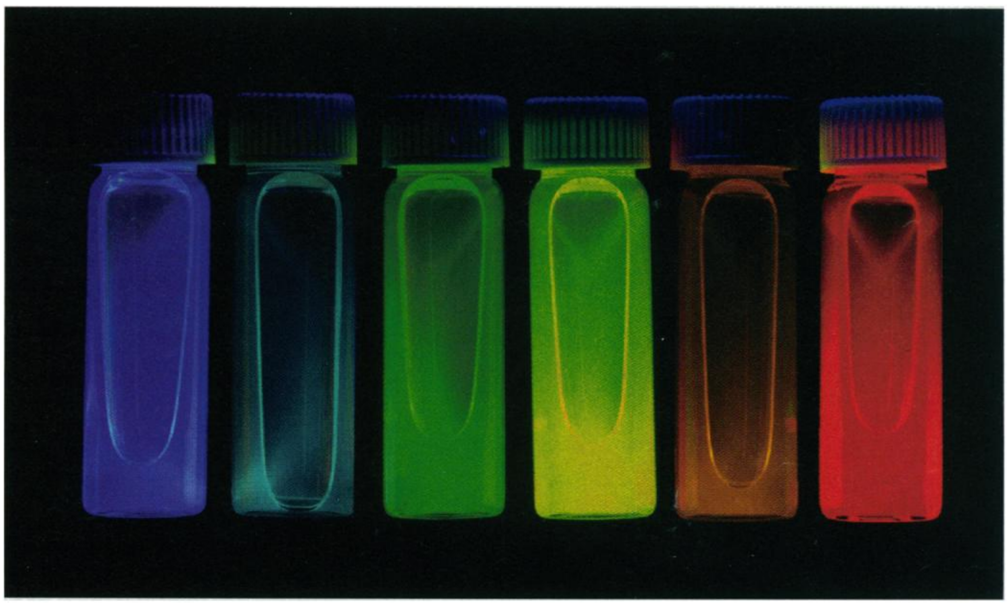
Membranes under stress. These two microscopic images show palladium deposited on silicon oxide membranes. The structures were fabricated as a test system for a microfluidic chemical device. The silicon oxide is under compressive stress, which causes the membranes to buckle; the location and extent of the defects caused by the buckling are apparent. The image was taken with Nomarski optics. The silicon oxide membrane was 1 μm thick and the palladium film was 0.2 μm. The membranes are 500 μm wide. The more intensely colored photograph provides additional insight into the buckling modes. [Scientific investigators: A. Franz, S. L. Firebaugh, K. F. Jensen, and M. A. Schmidt, Massachusetts Institute of Technology]‡



Proteus patterns. This picture captures the dynamic response of bacterial colonies to outside stimuli. By eliminating the edges of the petri dish in framing this composition, the patterns become immediately apparent. The image will appear on the cover of *Science and Engineering Indicators*, a yearly publication of the National Science Board. [Scientific investigator: J. Shapiro, University of Chicago]‡

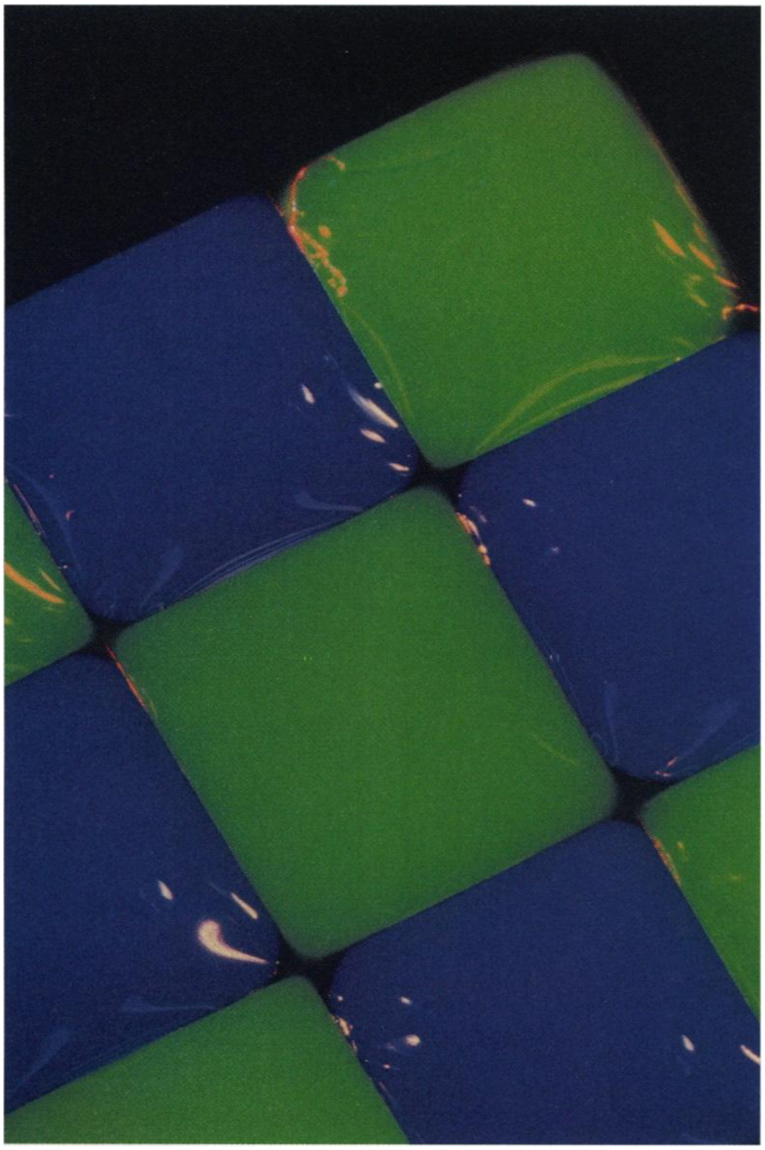


Adhesion. A microscopic image of clear tape as it is being pulled off a silicon chip. Nomarski differential interference contrast was used to emphasize edges and abrupt changes in refractive index. The "fingers" formed by the adhesive are about 200 μm long. [Scientific investigators: M. Chaudhury and B. M. Zhang, Lehigh University]‡



Vials of nanocrystals. These six vials contain nanocrystals of cadmium selenide of increasing size. The image was taken with ultraviolet light; the vials were placed lying down and photographed from above. The air bubbles add subtle compositional interest without detracting from the information. A similar image appeared on the cover of the *Journal of Physical Chemistry*.* [Scientific investigators: M. Bawendi and K. Jensen, Massachusetts Institute of Technology]‡

MURAL: TERESE WINSLOW



Colored square drops of water. The precision of the pattern is emphasized by fluorescing dyes added to the water drops on a patterned self-assembled monolayer on gold. The sides of each square are about 4 mm long. By coincidence, the picture proved that no leakage was taking place at the 1-μm-wide hydrophobic lines between the squares. The picture, taken with a Nikon F3 and a 105 macro lens, appeared on the cover of *Science*.† [Scientific investigators: N. L. Abbott, J. P. Folkers, and G. M. Whitesides, Harvard University]‡

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semble "art" books, they are not art. I do not view myself as an artist because an artist has a personal agenda and a very particular point of view, that of communicating the part of herself she wants the world to perceive. One may view the images I take as artistic, but their primary purpose is to communicate scientific information. My photographs are spare—compositions of three-dimensional forms and structures recorded on two dimensions. I frame the images in a way that emphasizes the particular point of the investigation, carefully choosing only the components essential for communicating a specific idea; more details do not necessarily add clarity. I find a readable order in the data, a hierarchy of information, guiding the viewer's eye to know where and how to look. If I digitally eliminate a dust particle or scratch, I indicate that I have done so. In sharp contrast, an artist is not necessarily committed to conveying data and may inadvertently subvert the essence of scientific investigation, its intellectual rigor, so to suggest that art and science are related may dangerously redefine each. Scientific images may be beautiful and even artistic, but they are not art, and art is not science.

In fact, perpetuating a false connection between science and art cannot provide a permanent basis for greater public interest in science. Science itself in its wonder and beauty can attract enough attention, even if at first it is only a glance. While amateurs, in the true sense of the word, do not *deeply* understand science, one should not underestimate the power of their enthusiasm. Although my enthusiasm is enriched with an understanding sufficient to ask the right questions and to fashion the appropriate visual vocabulary much as scientists use equations and formulae, the enthusiasm from the public is just as important in the long run. That enthusiasm will expand only when science is made more accessible. Accessibility is the first step to convincing the nonscientific community that scientific illiteracy is no longer acceptable. It will encourage the confidence to be curious, and that curiosity will be reason enough to look at the remarkable world we investigate, question it, and then attempt to understand it. But first, we must all begin to *see* it.

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*M. Bawendi and K. Jensen, *J. Phys. Chem. B* **101**, 13 November 1997.
†N. L. Abbott and G. M. Whitesides, *Science* **257**, 1380 (1992).