FIVE NOT-SO-EASY PIECES

Notes from the Photographer

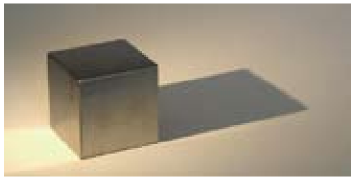
From the beginning, George Whitesides and I understood that many of the images in *No Small Matter* would, of necessity, be metaphoric in order to communicate the invisible complexity of the micro and nano worlds. He started a list, which eventually expanded with various potential concepts coming from both of us. To suggest the nature of reality, George at first proposed a salami sandwich ("or pick your spread—peanut butter would be fine, but the filling has to show, and it has to be thin"). At that moment I panicked, thinking I was in deep trouble—I'm not good at salami. But over time we worked our ideas back and forth until we were both satisfied with the representation, scientifically and aesthetically. Our two perspectives became complementary. I presented him with a variety of photographic ideas that seemed to capture key concepts, and nudged him to think and write metaphorically. And his creative explanations of the science encouraged me not to be content with rounding up the usual suspects, or with just another pretty picture, but to aim for something more expressive.

To illustrate the counterintuitiveness of the quantum world, I started with an image of a modified mosque and ended up with an image of a glass apple. How did this happen? In the first image, I was attempting to create a place that could never exist, by digitally combining what I thought were two incompatible buildings: the Salk Institute in La Jolla and the Hagia Sophia in Istanbul (both taken in my former life as an architectural photographer). But after some of my colleagues called the new "place" beautiful, I knew that the image wasn't suggesting the idea of uneasy contradiction that I had in mind. So I dumped it and moved on.

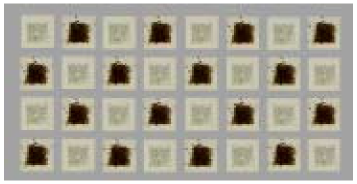
I had always loved a glass apple that my late husband received as a teaching award in surgery. It is both visually and tactilely pleasing, and seemed in some way to crystallize the notion of a quantum world where an apple isn't really an apple anymore. I photographed it from an overhead angle,

and when this was unsatisfactory, I tried a more frontal point of view—much better, although a distracting reflection from one of the light sources had to be digitally deleted.

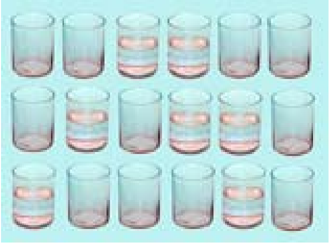
The next challenge was how to suggest the idea of contradiction without screaming it at the reader. The solution, I decided, was in the shadow. The only thing I could find at the time to cast the shape of shadow I needed was a metal cube. I digitally pasted just the cube's shadow onto the apple photograph, and then stretched, pulled, and distorted it, trying to evoke a sense of counter-intuition. At one point I even cut a square hole in the shadow—a bit of overkill, I admit. After that, I decided that a simpler rectangle of shadow would work just fine.



THIS WAS ONE of the first images I began to think about for this book. At first, my understanding of exactly what "binary" means was not clear. I thought I needed to show not 0's and 1's (nothing and something) but two states (this and that). So I started with a random pattern of colored glass pebbles, with no intended numerical meaning. In a second try, I used a more identifiable material, although few readers would guess that what they see on the left is salt and pepper.



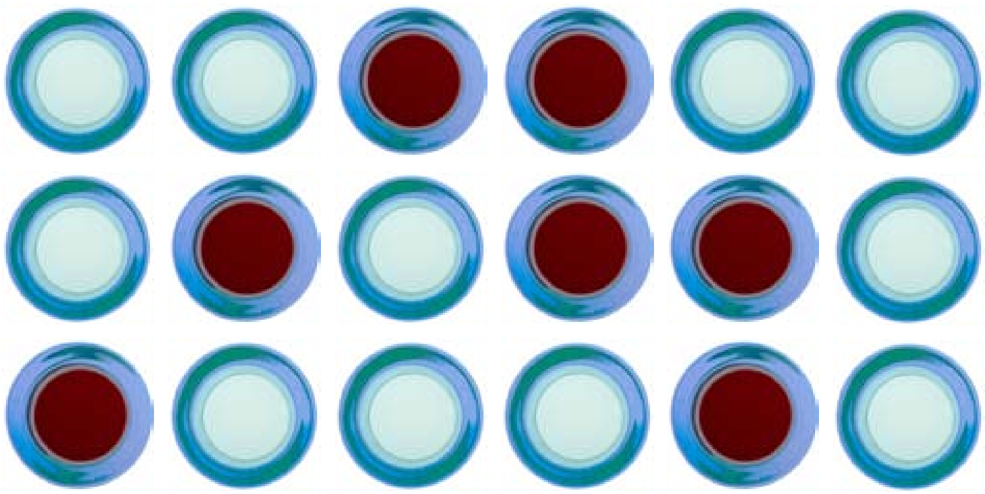
George was concerned about the regularity of these images and suggested a pattern that could be translated into a binary equation. And to capture the idea of electron flow, he asked me to use a liquid that is present or not present in some sort of vessel. I began with water in one of my favorite sets of glasses and then tweaked the image in Photoshop. But when trusted friends told me the result was difficult to "read," I shifted the camera to an overview.

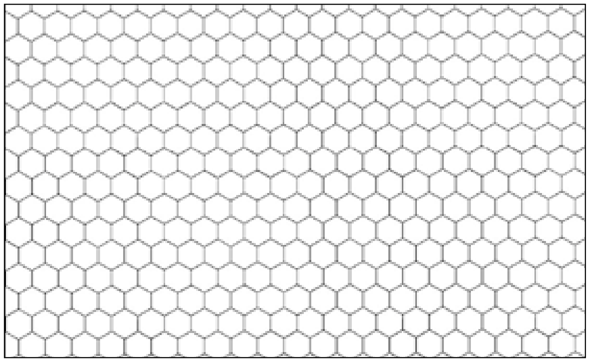


In what turned out to be my final shot, I filled a heavier glass with a wonderful Shiraz I was eager to try and photographed it, along with another unfilled glass. The result was quite satisfying (as was the glass of wine, which I emptied in celebration).

	Top row	0 0 1 1 0 0
+	Second row	0 1 0 1 1 0
=	Bottom row	1 0 0 0 1 0

Representing 12 + 22 = 34

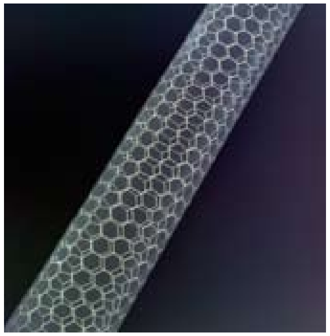




When we decided to include an image of nanotubes, I approached the project photographically, as I usually do. But in my mind, the obvious image—a scanning electron micrograph—was not an option, because others have already done that, and much better than I probably could. The most productive course, I decided, would be to simulate nanotubes.

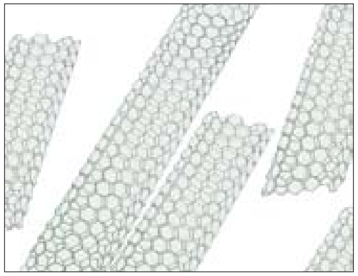
First I printed a black hexagonal pattern, representing a standard graphite lattice, on an 8x10 piece of transparent acetate. As I began to roll the acetate to make a tube, I had to decide how to connect the edges of the paper. Scientific sources informed me that there were indeed various possible configurations for carbon nanotubes, and that the ultimate configuration was significant in determining the electrical properties of the structure.

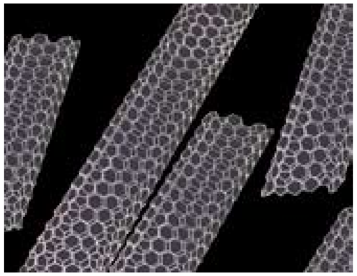
I decided (for aesthetic reasons) to adopt what's called the "zigzag" configuration. I secured the edges of the acetate with a couple of pieces of tape and placed the tube on my flatbed scanner.

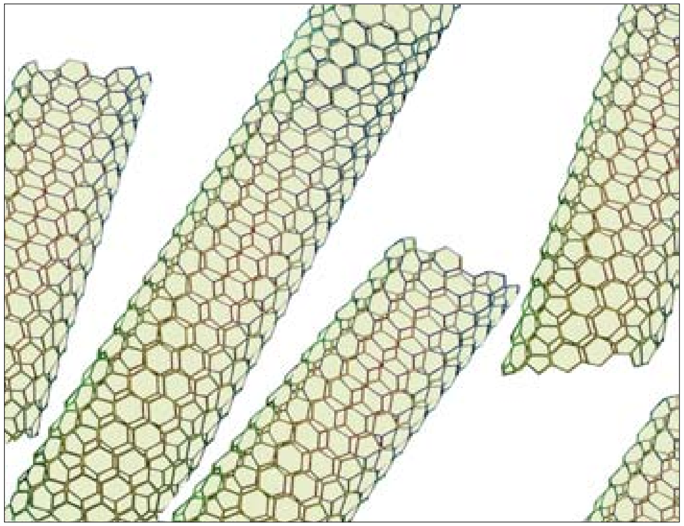


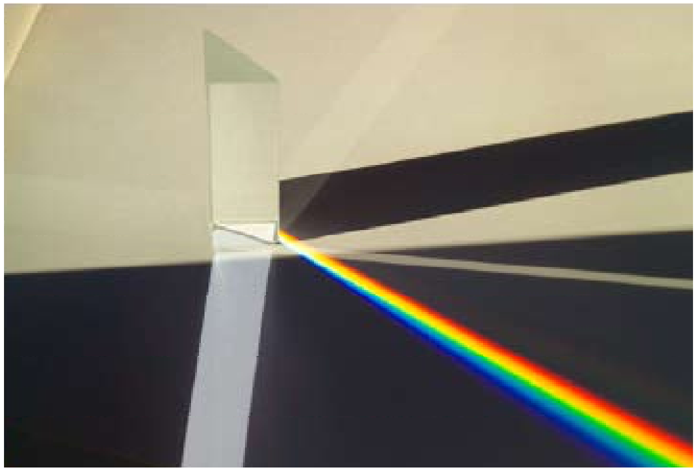
The result was not terribly compelling. I then “inverted” the nanotube in Adobe Photoshop. Going further, I combined a few replications of the image to make multiple layers with varying degrees of transparency. Then, for what I thought would be the final composite, I adjusted the image using various filters and additional inversions.

The act of researching and creating this image taught me quite a lot about nanotube science. Whoever you are—a photographer manipulating a scientific image in today’s virtual darkroom, a physicist sketching on a blackboard, a student reaching for a visual metaphor or graphing a function—understanding often comes through the act of representation.





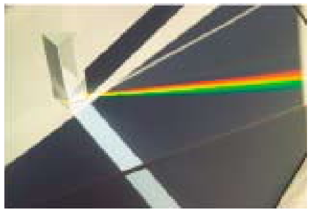


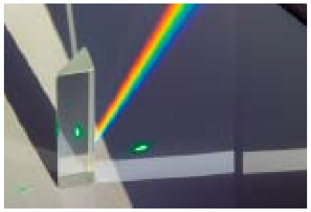


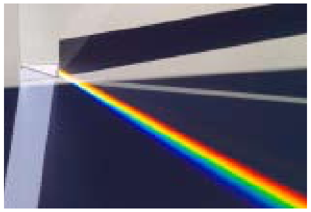
When George and I began our list of possible images, he wrote to me that "most of quantum mechanics turns out to be represented in interference and diffraction." He went on to suggest a few ideas for that concept, including a standard-issue photograph of light dispersed within a prism. So using a glass prism I purchased on eBay (which came in a "handsome, black, soft flannel travel bag"), I tried a number of garden-variety photographs, some with a green laser pointer along with varied light from a window.

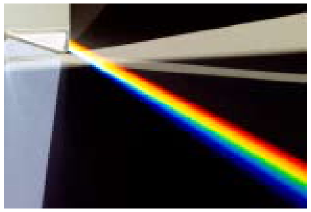
None were satisfying, even after cropping. For days, I walked around my house holding the prism and seeing some pretty spectacular spectra displayed on walls, ceilings, sofas, and all the rest. But again, nothing that I hadn't seen before in a textbook or blog jumped out at me.

Finally, on a cloudy day, I found what I was looking for. I propped the prism on a couple of leather boxes (which happened to have stitching) in front of venetian blinds drawn on one of the larger windows. The contrast between the



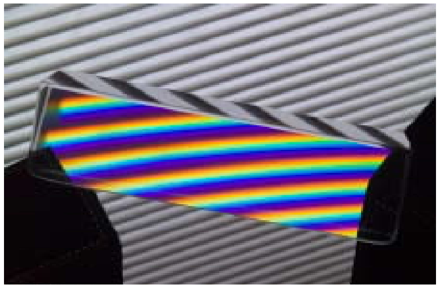


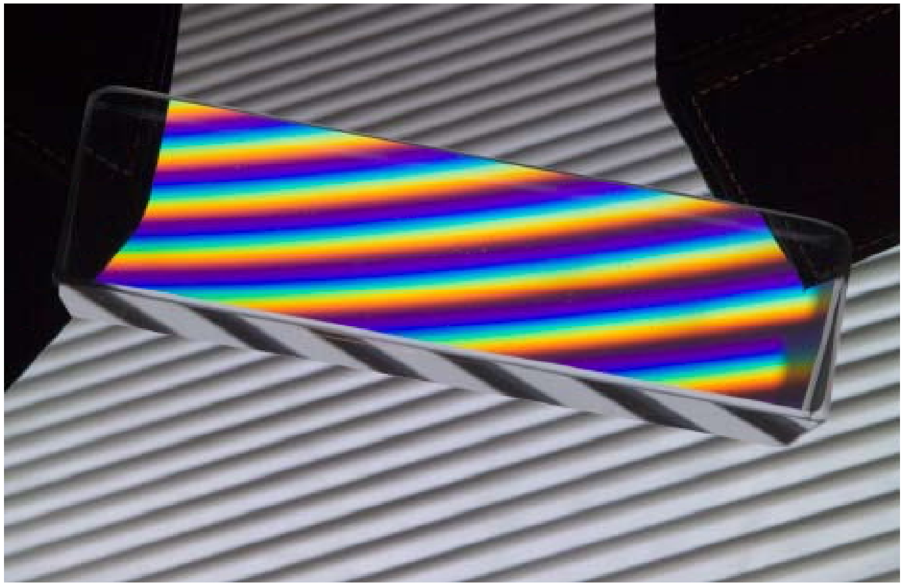


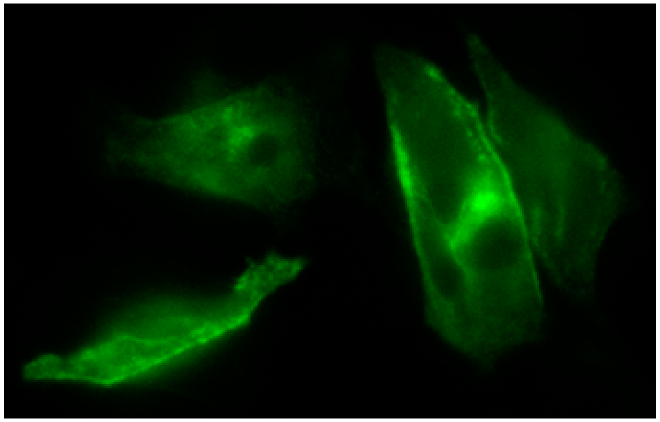


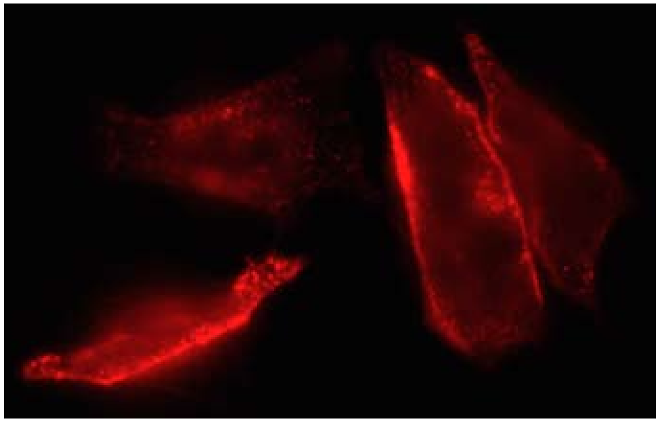
black and white pattern of the blinds and the brilliant colored lines inside the prism was dramatic and surprising.

For the book, I rotated the image 180 degrees. It just looked better.



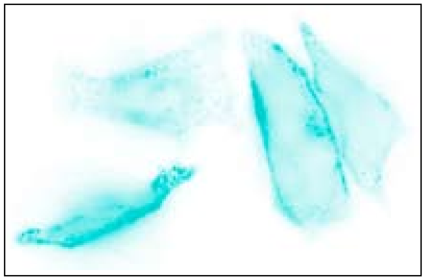






Alice Ting and Peng Zou supplied me with two of their original images. The colored areas give highly detailed morphological information about the cell, as specific quantum dots attach to specific structures. When the dots are excited with ultraviolet light, they fluoresce and so we see where they attach.

In standard views of fluourescently labeled material, the colored areas are set against a black background. I thought it would be interesting, and perhaps informative, to see the information differently, as long as I maintained the integrity of the science. So I "inverted" the two images in Photoshop to get a white background. But because it was important to keep the original colors for the structures themselves, I changed the colors back to the red and green.



I then layered both of the images over a third image taken with standard microscopy, again supplied by the laboratory. The three-layered result shows the same information as the original separate images, with the addition of a sense of the whole.