



Felice Frankel

Scientific Discovery Through Visualization

At a Glance

Felice Frankel, a research scientist at MIT who works in science photography, uses a variety of imaging techniques to capture stunning portrayals of nature's phenomena, blurring the lines between art and science. Frankel uses a PowerBook running Adobe Photoshop in Mac OS X to create her visual expressions, which help scientists communicate in new ways while making science more accessible to everyone.

Apple Solution

Frankel uses Apple hardware and Mac OS X in her working process. Since the introduction of Aperture, she has streamlined her workflow with a centralized location from which she can use visualization tools to analyze and process data. She sees Photoshop and Aperture working hand in hand to pass images back and forth without the need for document translation.



A 3-cm drop of ferrofluid on a glass slide. A slip of yellow paper sits below the slide and a set of seven small circular magnets under the paper affects the form of the drop.

As one of the world's leading science photographers, Felice Frankel combines a scholar's knowledge of science, a photographer's skill for visualization, and a designer's intuitive sense of aesthetics.

She started out as a biologist and lab technician. She later became a landscape and architectural photographer, earned a fellowship in design at Harvard University, and went on to work at the Massachusetts Institute of Technology as an artist in residence, eventually becoming a research scientist in the School of Science. In July 2006, she will become Senior Research Fellow at Harvard, as part of the new Initiative in Innovative Computing, while maintaining a part-time office at MIT's Center for Materials Science and Engineering as a research scientist.

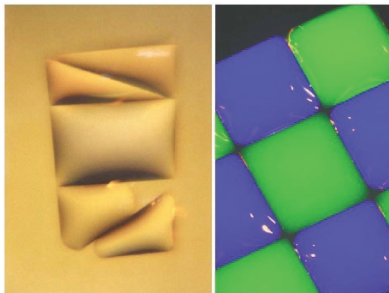
Frankel works with many of the world's premier scientists by documenting stunning examples of their research. Her work is beautiful, accurate, and—most important—communicates results and inspires ideas. She uses her Mac to create images that have graced numerous covers of the world's most respected journals, including *Nature* and *Science*. A recipient of grants and awards from the Guggenheim Foundation, the National Science Foundation, the National Endowment for the Arts (NEA), and the

Communicating with New Technologies

Frankel recently explored the world of podcasting when she was interviewed by *Science & the City* for its first “exhibit-cast.” Enhanced podcasts are a new way to explore a subject with visual content. Frankel is interviewed as she walks through a New York University exhibit showcasing her work. As she describes each piece, the image is displayed in iTunes or on an iPod (akin to the album art feature).

“It was fun,” she says. “I think there’s a whole world here of science images that we could learn so much from just by looking at them while listening to someone talk about them.”

Frankel is also exploring using the Mac OS X Dashboard feature to push the availability of science visualizations. “As a follow-up to the Image and Meaning workshops, we want to create a widget to open a portal for online collaboration of images and graphics in science,” she says. “We’re working with Harvard’s Initiative in Innovative Computing and Sigma Xi, the Scientific Research Society.”



The first image is the scientist’s initial cut (photo by Nicholas Abbott). In the second, Frankel combined ultraviolet and tungsten lights with fluorescing dyes in the water squares. Each square drop of water measures 4 mm. The image appeared on the cover of *Science*.

Alfred P. Sloan Foundation, Frankel is also the author of *Envisioning Science: The Design and Craft of the Science Image* and the co-author with George M. Whitesides of *On the Surface of Things: Images of the Extraordinary in Science*. A follow-up, *No Small Matter*, will be published by Harvard University Press.

Her tools for turning impenetrable data into meaningful visual representations that are also striking works of art include Apple hardware, Mac OS X, and visualization software.

In science photography, “truth telling” is the key component of every project. The workflow must be a carefully documented and controlled process. Analysis takes place sitting in front of the computer. And having the right tools on hand is crucial to making this process efficient and enjoyable.

Frankel and Her PowerBook Computers

Frankel’s PowerBook G4—she has three of them—goes everywhere she goes. During her rare stationary moments in the office, she uses a Power Mac G4 with an Apple Cinema Display. Her decision to use the Mac was simple. “There is no question that using a Mac is more intuitive,” she says. “It’s just logical.” But it goes even beyond that. “Frankly, there is something about the design of Apple’s products,” she adds. “You can feel that these people know that design is important, so we all must be part of the same community. There is something relevant about using a beautiful piece of equipment when you are working with a subject that is, in itself, beautiful.”

In *Envisioning Science*, she suggests that the methods scientists use in representing visual data should be fully documented, just as those for gathering nonvisual data are. “It’s time that graphics and images are taken just as seriously as explanation with text,” Frankel says. The reader must be provided with a visual history illustrating how the data was translated into its published form. “I think it’s finally beginning to happen,” she says. “Recently, for example, *Nature* has developed a set of new guidelines on how to submit images, addressing this point and also emphasizing the need for less manipulation.”

Frankel’s first cover for *Science* shows how a science photographer can turn a scientist’s results into a visualization both captivating and communicative. George M. Whitesides, a world-renowned scientist at Harvard University’s Department of Chemistry and Chemical Biology, brought the initial image to Frankel. The new image communicates the chemistry and at the same time clarifies the science for Whitesides.

Aperture’s nondestructive image processing, which retains original RAW data as a digital “master,” along with powerful versioning capabilities, helps photographers preserve their workflow and accurately cite the image-creation process.

“I like the fact that I don’t have to be terrified that I’m going to do something permanent,” she says, about working in Aperture. “Everything that you do is versioned and doesn’t affect the master. That’s quite significant for people in the sciences because we have to retain the initial image.”

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Communicating Science with Images

Frankel’s Image and Meaning workshops bring together scientists from a wide range of disciplines to focus on the visual representation of their data. The conferences’ interdisciplinary nature gives scientists the opportunity to share ideas. Visual expression gives them a common lexicon with which to break down barriers and stimulate collaboration.

“It might surprise you, but we do deal with similar issues, whether it’s oceanography or solar thermal expression,” Frankel explains. “Whether it’s underwater collection of data or out there in the solar winds, the representation of this data is very similar. Unfortunately, you rarely see scientists from different disciplines talking with each other. This is what we’re trying to change during these workshops—to get more communication going among the disciplines.”

Although advancements in communication and interdisciplinary sciences are key to Frankel’s message, she doesn’t want the individual relationship between scientists and their data to be overlooked. Seeing data that you are intimately familiar with presented in a new way can be a powerful tool in the scientific process. None of this would be possible without advancements in computing.

“It’s the computer and its amazing power that have given us insight that we would never have realized,” she says. “It has truly changed the way science has developed and will continue to develop.”

Aperture Brings New Level of Focus

Frankel uses a variety of software but has traditionally focused on Photoshop.

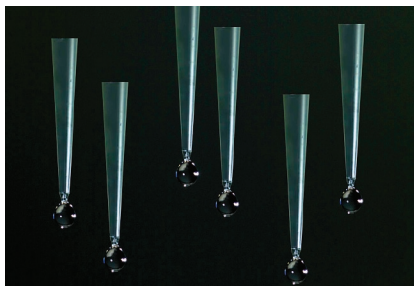
“Photoshop is essential, but I’m also enjoying my recent introduction to Aperture. The problem I find with Photoshop is that, for a scientist, there’s just too much there. We want to be as honest as we can with our images, so we don’t need all those bells and whistles.” Aperture now lies at the center of her workflow, ingesting new images from the camera and old images from Photoshop.

“There are two basic things that are wonderful,” she says. “First, it gives me an opportunity to organize images and to quickly compare and contrast them. It’s a major addition to my working process to no longer have to open every 50-megabyte file to compare how things look, which in the end takes a lot of time. It’s a joy to use Aperture to quickly view and organize my images.”

Although Aperture’s organizational and image-processing components are central to its value, users can enjoy the fluid interface on a daily basis. “There is a learning curve to Aperture, but it’s all very intuitive,” adds Frankel. “For instance, the magnifier is absolutely brilliant. Aperture uses a new kind of thinking—although it’s an incredibly logical kind of thinking—that is key for me. Aperture will be terrific for scientists; I’m very excited about it.”

Motivations for Advancements in the Field

Communicating results and ideas through visual expression is, of course, nothing new, but Frankel is finding new audiences and breaking new ground by developing science photography into a mainstream field of its own.



A part of a new series Frankel is working on (with George Whitesides) for an upcoming book, *No Small Matter*, which explores nano- and microscience, this image focuses on the “skin” (only a few atoms thick) that forms on a water drop.

Tools of the Trade

Operating system

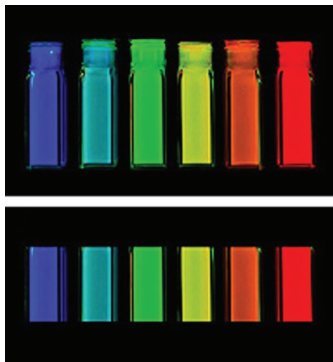
- Mac OS X Tiger

Hardware

- 12-inch PowerBook G4
- 15-inch PowerBook G4
- 17-inch PowerBook G4
- Power Mac G4
- 23-inch Apple Cinema Display
- Kodak DCS Digital Camera
- Nikon D1X Digital Camera
- Nikon F3 Film Camera
- Epson Perfection Flatbed Scanner
- Nikon Film Scanner
- Imacon Scanner

Software

- Aperture
- iWork (Keynote)
- QuickTime 7 Pro
- Adobe Creative Suite 2
- Dashboard
- Safari
- Adobe Acrobat Professional 7
- Nikon Film Scanning Software
- Macromedia Flash
- Mozilla Firefox
- Eudora
- FileMaker
- Fetch



“We are beginning to take the visual expression of science more seriously and will, in the end, advance thinking,” Frankel says. “Thinking visually and finding the best way to communicate those thoughts is another way of considering science. Eventually, the best scenario would be to create a multidisciplinary visual profession.”

Through her images, books, and workshops, Frankel endeavors to open the eyes and ears of both academia and the general public. She is deeply involved in the Picturing to Learn project, which teaches students to engage in science through visual expression. “I think people are very curious about the world around them,” she says. “And in their guts they know that there’s a lot of science involved. But they’re fearful of asking questions. Scientists have been using a language that’s inaccessible.”

She wants to change that. “It’s with visual language—such as pictures and graphics—that we can help people feel less intimidated,” she says. “It’s the visual language with which we’re all familiar that allows us to talk to each other about an image, point out parts that are interesting or beautiful, and ask questions without hesitation. That’s the bottom line for me: to make science accessible by revealing the beauty that’s already there.”

Frankel has seamlessly brought science, art, and technology together to create a new hub for the expression of ideas in the scientific community. The many labels—photographer, scientist, artist, designer—might just be perfect for a woman who believes so strongly in the advancement of interdisciplinary studies. Frankel has been building bridges between the separate disciplines her entire life.

“This is about turning the world on to science,” she says. “It was technically easy for me to get into this world because of Apple, and that gave me the freedom to concentrate on the more creative issues. Honestly, that’s for real.”

New Perspectives Inspire New Ideas

A salient example of the power of visual expression arose when Frankel was working on her image of six cuvettes of nanocrystals. While experimenting with how to present the data, Frankel decided to further the abstraction by cropping the top and bottom of each cuvette, effectively removing any reference point to the nanocrystals’ containers. After seeing the data presented that way, MIT scientist Mounji Bawendi immediately thought of a potentially new application for nanocrystals related to the color bar codes that the new image resembled. The cropped image offered him a new perspective—a new way of seeing something he had been working on for years.

“Visual expression is not only a way to speak with the general public and communicate with other scientific disciplines,” says Frankel. “The process of finding a way to visually represent an idea clarifies the science for the scientist. The process makes you think differently.”

For More Information

For more information, please visit www.apple.com/science.