may bias a cell toward the NF-κB pathway as a response to TNF, rather than toward death.

Still another set of proteins that has been tied to the TNF pathways may play a role in determining whether a cell is primed for death. These are the mysterious IAPs, for inhibitors of apoptosis, discovered in 1993 by Rollie Clem, a graduate student with Lois Miller at the University of Georgia. Clem found the IAPs while searching for the genes an insect baculovirus uses to keep its host cells from dying before the virus replicates. But the IAPs have mammalian counterparts as well.

The first to turn up, a year and a half ago, was the neuronal apoptosis inhibitor protein, NAIP, which has some structural resemblance to the viral IAPs. It was discovered by Alex MacKenzie's group at the University of Ottawa, as the product of the gene mutated in some forms of spinal muscular atrophy, a fatal human disease in which motor neurons in the spinal cord die off during embryonic development. MacKenzie's team went on to show that the normal NAIP protein protects neurons from death.

Even closer relatives of the viral IAPs were discovered in fruit fly and mammalian cells by several labs. Some of these cellular IAPs block apoptosis, but researchers still don't know where or how they exert their effects. One clue, coming from Goeddel's lab, is the discovery that the IAPs form a complex with TRAF1 and TRAF2, suggesting that they act early in the pathway, but no one knows the biochemical consequences of the interactions.

Despite that uncertainty, some researchers suspect that the IAPs might act as a switch that can determine what path the TNF message takes. Vaux suggests the IAPs could bias cells toward the NF-κB pathway, perhaps by drawing TRADD to TRAF2, thus preventing TRADD from interacting with MORT1/FADD to trigger the death pathway. "That is a very attractive model," says Chicago's Thompson, but he notes that there is no evidence for it yet.

Even if that model turns out to be right, it is unlikely to be the whole story, for there are other factors that might influence a cell's propensity to suicide. These include the presence and levels in the cell of a protein called Bcl-2, whose mode of action is not yet known, but which also protects some cells from death.

One thing is certain: The vulnerability to different death signals and the ability to be saved from death by different inhibitors of apoptosis varies from cell type to cell type. Even among one general cell type such as lymphocytes, some subtypes succumb to Fas activation while others are oblivious, and some are killed by TNF while others are spurred to produce more inflammation.

These divergences have led researchers to conclude that while the general stations on the way to death—such as MORT1/FADD or the ICE enzymes—may be widely used, there are countless variations, side trails, or alternate routes that lead from death receptors to the agents of death in the cell. For example, each cell type may have its own constellation of ICE enzymes, each with its own unique profiles of activators and inhibitors, as well as its own characteristic levels of FADD, TRADD, TRAFs, and IAPs, that nudge the cells toward or away from death. "It is probably the balance [of all these things] that determines whether a cell will succumb or not," says Michigan's Dixit. And that means that the mappers of these pathways have their work cut out for them for years to come.

–Marcia Barinaga

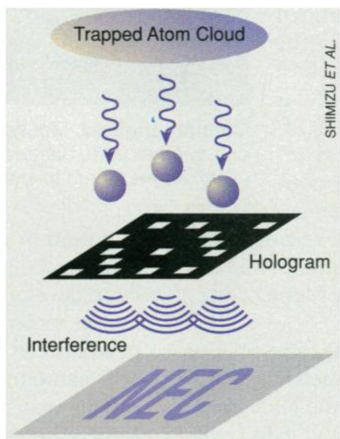
PHYSICS

Painting Pictures With Atom Waves

In a famous haiku, the 18th-century poet Ryota wrote of the mysterious beauty of "cherry blossoms left unwatched." An echo of the phrase lingers in quantum mechanics, which says that matter acts like a wave as long as it is unobserved, then changes character when measured, collapsing into point particles. The echo may have gotten stronger with new work by a Japanese research group.

Using optical principles to control the unseen waves of neon atoms, researchers at the University of Tokyo and the NEC Fundamental Research Laboratories in Tsukuba coaxed the atoms to form a minute physical image. The work, says Mara Prentiss, a physicist at Harvard University, is "an elegant and beautiful demonstration" of quantum mechanical duality and could provide a new technique for etching intricate circuit patterns.

Reported 2 weeks ago in *Physical Review Letters* by Fujio Shimizu of Tokyo and his colleagues, the experiment "does with atoms what people have [ordinarily] done with light," as Wolfgang Ketterle of the Massachusetts Institute of Technology puts it. It mimics optical holography, in which an image is encoded in the interference pattern of light and dark patches created when two laser beams overlap—one reflected from the original object and another serving as a reference. When a "readout" beam passes through the holographic pattern, usually recorded on film or in a special crystal, an image of the object is regenerated.



Quantum artistry. Interfering atom waves yield image.

Swapping light for atoms was not simple. The researchers knew that bouncing atom waves off an object to make a hologram was impractical—the analogy between atoms and light doesn't stretch that far. What's more, there are no crystals capable of recording atomic interference patterns. So the team simply calculated the hologram that would be needed to read out a particular image—in their case, the letters "NEC"—and then etched holes, analogous to the bright areas in the interference pattern, into a membrane, using a technique called electron-beam lithography. The result looks something like the computer-punched holes on old payroll checks.

The researchers then positioned the membrane beneath a source of neon atoms, whose random motions had been damped by bombarding them from all sides with laser light. When Shimizu and coworkers released these "cooled" atoms, they fell toward the membrane at almost the same speed, forming a coherent atom wave. As the wave diffracted through the holes, it interfered with itself and impinged on a fluorescent detector. There the individual atoms were resurrected, producing point-like flashes that, over a 2-hour exposure, summed to produce a fuzzy reproduction of the NEC logo, about a millimeter across.

That's far too coarse and slow for practical uses, but "it's a completely new way to generate a pattern of atoms," says Jabez McClelland of the National Institute of Standards and Technology in Gaithersburg, Maryland. And Shimizu thinks that with a more finely detailed hologram, his team could make atom-wave images with features as small as a few hundred nanometers—in principle, as small as the holes that can be etched on the mask. Because the barrage of atoms could etch away a substrate, the method might then be useful for making minute circuit patterns. The practical downside, says Harvard's Prentiss, is that the resolution can be no better than that of electron-beam lithography, which creates the holographic "templates."

But Shimizu's interest is aesthetic as well as practical. "It is fun to produce a pattern that cannot be imagined from the mask." And that approach might just raise the science of quantum imagery to an art form.

–James Glanz