the retinas of mutant flies to pass signals to one another. When they stimulated a neuron, that neuron responded—but its signal did not get transmitted to the next neuron. What's more, the tips of the nerves, at the synapse, appeared to have degenerated.

Other investigators are excited about the method the Benzer team used to show that the cysteine string protein actually has a crucial synaptic function. "This paralysis phenotype shows just how potent genetics can be in showing that a [synaptic] protein really is important," says Schwarz. The genetic method doesn't, however, show precisely what that function is—that is where the work of the Gundersen team comes in.

Their work suggests that the protein may be necessary for the release from the nerve tip of the neurotransmitters that carry the nerve signal across the synapse to the next neuron. The group came to this conclusion because they found that in nerve cells of a fish called the torpedo ray, the cysteine string protein is anchored to the surface of the synaptic vesicles, tiny membranous sacs which contain the neurotransmitters prior to their release into the synapse.

Gundersen speculates that the cysteine string protein on the surface of the vesicle may help open calcium ion channels in the tip of the neuron, triggering the calcium influx that is needed for the synaptic vesicles to spill their contents into the synapse. "One can imagine," he says, "that when the vesicle gets close to, or docks at, the presynaptic membrane, it (the cysteine string protein) interacts with the calcium ion channel." And, in fact, that fits with earlier work from the Gundersen lab that hinted that the string protein might regulate, and so possibly associate with, calcium ion channels.

If Gundersen's theory is correct, one would predict, he says, "that if you stimulate a nerve in a *Drosophila* mutant you should see inhibition of the calcium influx." And that's exactly what Zinsmaier intends to test next. Using calcium imaging techniques, he says, "we can visualize the presynaptic calcium influx, and see whether or not it is altered in our mutant flies." Meanwhile, the Gundersen team is trying another tack.

They want to know just how widespread cysteine string proteins are throughout the animal kingdom. If they find the protein and its gene in humans, says Gundersen, that will be a major cause for excitement. Efforts to understand neuronal degenerative diseases such as Parkinson's and Alzheimer's have been intense, but the underlying causes remain only poorly understood. If lack of the cysteine string protein causes neuronal degeneration in the fruit fly, he reasons, why not in humans, too? And if that proves to be the case, the once-obscure cysteine string protein will have truly arrived.

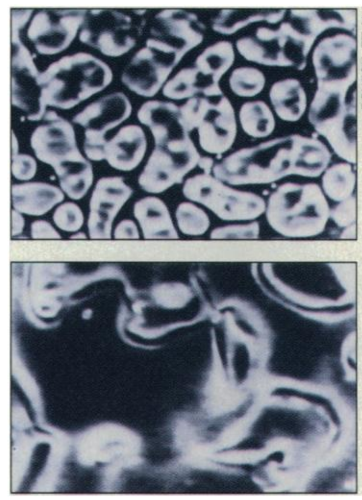
–Rachel Nowak

PHYSICS

Recreating the Universe's Fateful Flaws

Most people who gaze into crystals hope to see the future, but some physicists are now doing the reverse: peering into a drop of liquid crystal to see whether they can glimpse the beginning of time. As a liquid crystal cools, the material's rodlike molecules make an abrupt change from helter-skelter disarray to an orderly state, in which the molecules line up like logs in a raft. That process, some researchers believe, could be a model for a similar transition that took place in the first fraction of a second after the big bang. A liquid crystal, says Syracuse University physicist Mark Bowick, "is an excellent analogy [to the mathematics]."

On page 943 of this issue, Bowick and his Syracuse colleagues Eric Schiff and L. Chandar, along with Ajit Srivastava of the University of California, Santa Barbara, exploit that analogy as what Schiff calls a "reality check" on a cosmological theory. The theory holds that if various parts of the primordial universe made the transition independently, the change would have spawned "cosmic defects." These flaws in space-time could have seeded the growth of larger structures, such as galaxies, before gradually vanishing. Now, the Syracuse team has found that in the model universe of a liquid crystal, one kind of defect—threadlike "strings"—forms at about the rate implied by the theory. "It's nice to have experimental confirmation," says Brown University cosmologist Robert Brandenberger.



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Microcosm. Liquid crystal "domains" *(top)* merge, forming strings.

The scenario that the Syracuse group set out to test was originally proposed in 1976 by theoretical physicist Thomas Kibble of Imperial College, London. Kibble's starting point was a widely accepted account of changes in the newborn universe. At first, the fundamental forces, such as the strong and weak forces, were indistinguishable. This "symmetry" broke as the universe cooled and distinct forces emerged. The symmetry didn't break on its own, however; helping the process along was a hypothetical force field called the Higgs field, which gave space-time an overall "direction"—a mathematical abstraction analogous to the overall orientation of molecules in a liquid crystal.

Kibble argued that this process took place independently in many different parts of the universe, like curds forming in milk. As a result, the Higgs-imposed direction of space-time could differ for each curd, or domain. As the universe cooled further, the domains jostled together and merged, but sometimes their directions differed too much for them to merge smoothly. And, as Bowick puts it, "When neighboring domains can't jiggle to make everything uniform, you get defects trapped." Strings, for example, might be created at points where three or more irreconcilable domains met. That would happen at a predictable rate, Kibble said, depending on the range of possible domain orientations.

Bowick and his colleagues realized they could give Kibble's idea a real-world test in liquid crystals, because they form separate bubbles of the ordered phase—analogous to the Higgs-inspired domains—during the transition to order. Three years ago, Bernard Yurke of AT&T Bell Laboratories, Neil Turok of Princeton, and their colleagues showed that when these bubbles merge, they spawn all manner of "cosmic" defects, including threadlike remnants of the disordered phase resembling cosmic strings. As a test of the Kibble mechanism, the Syracuse team decided to see whether it could predict the number of strings in a liquid crystal.

Finding out what the Kibble mechanism predicted, however, was no easy task, as Srivastava and Bowick found; complications such as the influence of the top and bottom of the cooling layer on domain orientation forced the researchers to build a simplified computer model of the material. The model predicted that strings would form at a rate of about 0.6 per bubble. Then it was a matter of painstaking observation, says Schiff: "You see bubbles form, count the number of bubbles, measure the number of strings per bubble."

The actual number was, indeed, about 0.6 strings per bubble. "It's the first experimental verification that the idea is qualitatively correct," says Bowick. Turok agrees, but he puts the emphasis on qualitative. "To be honest, I'm not a hundred percent convinced by the numbers," he says, noting they reflect a lot of assumptions and approximations. And he cautions that demonstrating the Kibble mechanism in a liquid crystal doesn't prove that strings existed in the early universe or shaped its structure. For scientists, like the rest of us, crystal gazing has its limits.

–Tim Appenzeller