the Novartis Institute for Medical Sciences in London, approached the problem from the opposite direction. They searched DNA databases for sequences similar to the recently identified heat and capsaicin receptor and pulled out a mouse gene they called *TRPM8*. When transferred into cultured cells, the gene conferred cold and menthol sensitivity, the group reports in the 11 February online edition of *Cell*.

Although the two groups didn't realize it until a few days before their papers were published, TRPM8 and CMR1 are the same receptor. Neither group yet knows exactly how cold affects the receptor, but the "most straightforward" explanation, Patapoutian says, is that "colder temperatures change the conformation of the channel," allowing positive ions to flood into the cell. A similar adjustment could occur when minty-cool menthol binds to the receptor.

But "by no means can this [receptor] by itself explain perception of cold," Patapoutian says. "Other mechanisms and channels will be involved, given that humans can detect differences as little as 1°C."

Indeed, neurons with designated cold receptors aren't the only ones to feel a chill. Félix Viana and colleagues at Miguel Hernández University in San Juan de Alicante, Spain, propose that cold sensitivity results from an interaction among channels that hold potassium ions inside the cell and those that let them out—a process that has no need of a specific cold receptor. The team isolated a population of cold-sensitive neurons from the faces of mice. These neurons, when exposed to cold or menthol, close a so-called "leak channel" that normally allows positive potassium ions to trickle out of the cell, the researchers found. Closing the channel holds positive ions inside the cell, exciting the neuron, they report online on 11 February in *Nature Neuroscience*. These observations confirm similar findings in nonfacial neurons reported by Reid's group in January 2001.

Viana's group found another difference between cold-sensitive and cold-insensitive sensory cells that are otherwise quite similar. The latter seem to have a "braking" mechanism that is absent from cold-sensitive cells. This brake, called a voltage-gated channel, slows neural excitation by shuttling potassium ions out of the neuron, despite the closure of the leak channel. Cells' sensitivity to cold, therefore, rests not on the presence or absence of one particular channel but rather on "the unique combination of channels [the cells] express," Viana says.

Neurons aren't necessarily committed to a life of sensitivity or obliviousness to cold. Viana's team found that blocking the voltage-gated potassium channel in neurons normally impervious to cold made about 60% of those cells cold-sensitive. This mechanism could explain how nerve injury sometimes causes painful sensitivity to cold, the researchers suggest. Previous reports indicate that nerve injury disrupts certain voltage-gated potassium channels. If a neuron contains too few of these channels, the researchers suggest, it could become hypersensitive to cold.

"It looks like you have a population [of cells] that can become responsive [to cold] in the absence of CMR1," says neuroscientist Michael Gold of the University of Maryland, Baltimore. "My gut feeling is that in the end, it's going to turn out to be probably a combination of both," with specialized receptors working in concert with a balance of ion channels to let people know that, baby, it's cold outside.

–CAROLINE SEYDEL

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ASTRONOMY

The Tumultuous Teens of Supernova 1987A

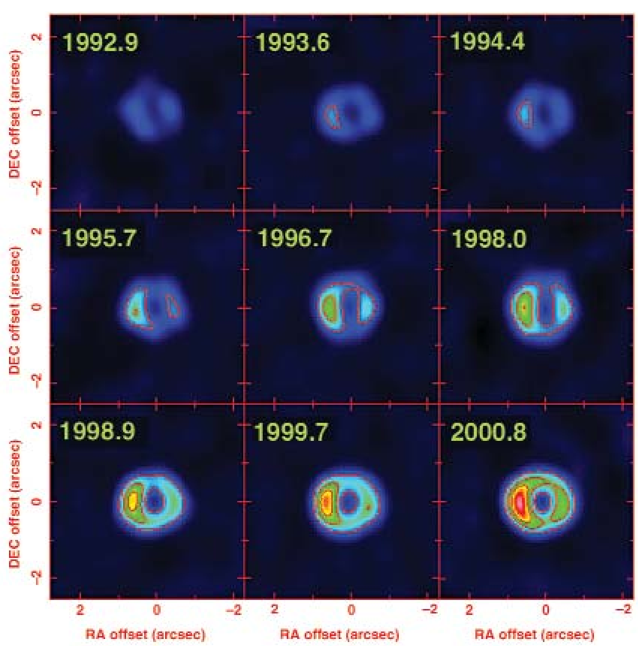
With the explosion long faded, the most spectacular star in centuries is treating astronomers to a rip-roaring new light show

When Supernova 1987A burst onto the cover of *Time* 15 years ago this week, astrophysicist Stan Woosley of the University of California, Santa Cruz, told the magazine: "It's like Christmas. We've been waiting for this for 383 years." Today, the supernova is the gift that keeps on giving. Although the explosion has dimmed, space around it now rages with energy. This maelstrom promises the closest look yet at how nature churns fresh elements into the cosmos.

The rebirth started a few years ago, when the supernova's blast wave hit part of a ragged ring of gas shed by the bloated star before it collapsed and self-destructed. Recently, that fierce impact has spread from a single "hot spot" to a dozen, and more are coming. "It's all going to become one solid hot spot," says astrophysicist Richard McCray of the University of Colorado, Boulder. "It will become 100 to 1000 times brighter in the next decade."

That's not bright enough to make 1987A visible to the unaided eye. However, the fireworks should reach beyond the inner ring to light up a puzzling cloud of gas and dust, also cast off by the star long ago. The shape and motions of this cocoon may reveal whether the doomed star had a companion. The shock wave itself will start to echo throughout the supernova's debris, reflecting like a sonic boom in a canyon. That chaos will disperse the star's pristine elements far into space: carbon, oxygen, iron, and heavier substances flash-forged by the explosion.

It's all part of 1987A's transformation into a supernova remnant like the famed Crab Nebula, whose explosive birth Chinese astronomers noted 948 years ago. This time, astronomers have a ringside seat with modern telescopes at their disposal. "We've never had a good record of how a supernova feeds heavy elements into the interstellar medium to make future stars and planets," says astronomer Arlin Crotts of Columbia University in New York



Tuning up. Radio waves from Supernova 1987A keep getting brighter as a shock wave boosts electrons to near the speed of light.

CREDIT: RICHARD MANCHESTER *ET AL.*/CSIRO AUSTRALIA TELESCOPE NATIONAL FACILITY

City. "Supernova 1987A will lay it out for us in exquisite detail."

Coasting toward a collision

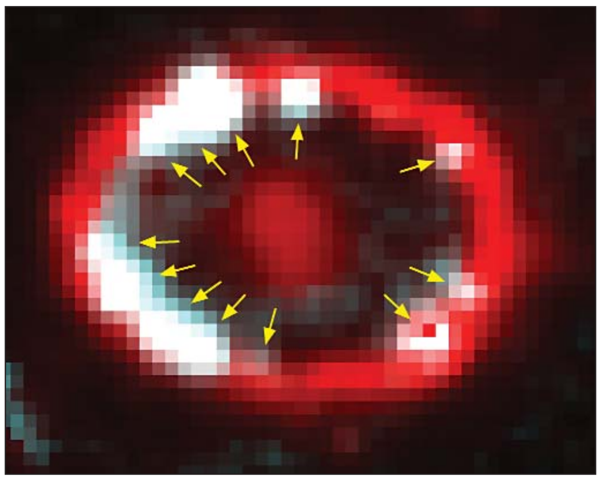
For many years after its detonation, which astronomers first saw on 23 February 1987, the supernova was in what Crotts calls a "coasting phase." Its blast wave—the leading edge of matter ejected by the explosion—raced at about 1/20th the speed of light through a cavity of mostly empty space about 2 light-years wide. Meanwhile, light from the explosion itself, fueled by the radioactive decay of unstable isotopes, faded inexorably. That glow is now just one 10-millionth as bright as it was at the supernova's peak.

Still, things revved up during the apparent calm of the coasting phase. As the shock slammed past leftover gas in the cavity, it boosted a growing horde of electrons close to the speed of light. Those electrons, whirling along magnetic field lines, began to emit strong radio waves. "The acceleration was in first gear for a while, then second, but now we're in third gear," says radio astronomer Bryan Gaensler of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. "It's already brighter in radio than it was 1 week after the explosion." The powerful blast has also scorched the sparse atoms in the round cavity and triggered high-energy x-rays, visible to both NASA's Chandra X-ray Observatory and the European Space Agency's XMM-Newton satellite.

Monitoring of the radio emission by the Australia Telescope Compact Array, a network of six radio dishes in New South Wales, has revealed a distinct mass imbalance in the cavity. Most energy streams from the eastern and western sides, near the plane of the former star's equator. That jibes with a scenario in which the bloated star lost much of its outer atmosphere along its rotating midsection, rather than from its poles, before it collapsed and exploded. By the time the shock wave reached the edge of the remnant in the past few years, the extra gas near the cavity's equator had slowed it down to about 3000 kilometers per second. That concussion—still moving at 1% of the speed of light—is sparking the newest fireworks. The shock plows into the innermost fringes of a ring of dense gas that the star emitted some 20,000 years ago, perhaps in a single puff like a hobbit blowing a smoke ring with his pipe-weed. The milder but still violent collision heats atoms enough to produce low-energy x-rays. And as the gas cools in the wake of the shock, the atoms shine in visible light that the Hubble Space Telescope can catch.

Hubble sees 12 hot spots and counting. Indeed, the optical flares now span much of the ring. Few gaps larger than 45 angular degrees remain, according to a paper submitted to *The Astrophysical Journal* by Columbia graduate student Ben Sugerman and his colleagues. The team's analysis suggests that some spots flicker on time scales as short as 1 month. "We think the shock is hitting disconnected clouds or breaks in the matter," says Crotts. Closely spaced observations with Hubble and with adaptive-optics systems on the ground will help astronomers use the shock to probe the structure of the inner remnant, he notes.

As the blast wave strikes bigger arcs of the dense ring, the barriers will propel intense "reverse shocks" into the matter ejected by the supernova. Initially, that matter will consist mostly of the dead star's outermost layers. But within 5 to 15 years, the shock's echoes will sweep across elements created deep within the star, according to models by McCray and others. McCray expects that radioactive "shrapnel" of nickel-56 shot far out into the blast from the star's core, rapidly decaying into cobalt and then iron. The resulting heat created foamlike pockets of low-density iron, he believes, within the rest of the higher density ejecta. Infrared data from the Kuiper Airborne Observatory suggest that such foaming action did indeed occur: About 1% of the mass in the remnant's interior appears to fill half of the volume, McCray says.



Ring of fire. A dozen hot spots (arrows) have flared as the blast from Supernova 1987A plows into knobs of gas; soon, the entire ring of gas, shed by the doomed star 20,000 years earlier, will blaze.

CREDIT: B. SUGERMAN *ET AL.*/COLUMBIA UNIVERSITY AND SPACE TELESCOPE SCIENCE INSTITUTE

Blue supergiant or deadly merger?

McCray is eager to witness another consequence of the shock wave's plowing into the entire ring. "It's clear that the ring is only the inner skin of a much larger volume of material that has remained invisible," McCray says. "The ring will be a new light bulb. As it heats up, it will gradually ionize the rest of the structure so that we can see it in x-rays. It will blossom like a flower in the next decade."

This flowering will yield more than pretty pictures. By studying its form and the motions of gas and dust in the nebula—which may contain 10 times the mass of our sun—astronomers should unearth the history of the star that blew up. McCray hopes this "interstellar archaeology" will help resolve an ongoing debate about Supernova 1987A's origins.

For years, astrophysicists maintained that the star ended life as a lone "blue supergiant," a smaller and hotter cousin to the red supergiants believed to spawn most supernovae. According to this picture, slow-moving billows of matter from an earlier red supergiant phase interacted with intense winds from the final blue phase to create the inner ring of gas. However, other researchers proposed a rather different idea: A smaller companion star merged with the giant star 20,000 years before it exploded, spewing out a flattened disk of dust. Astronomers do see binary systems inside other stellar remnants, so it's cosmically feasible.

Neither scenario, however, explains a pair of faint, larger rings that Hubble sees above and below the inner dense ring, forming a rough outline of an hourglass. "The evidence for either idea is all circumstantial," McCray says. "There is no proof of anything, and models have failed to create those structures." When the distant cloud starts to glow beyond the faint rings, astronomers hope to retrace the behavior of the star—or stars—that cast the gas and dust into space.

Supernova 1987A hides still other mysteries. Most notably, astrophysicists don't know whether a neutron star or a black hole now lurks at its core. Radio astronomers periodically check for pulses of radiation from a whirling neutron star, but so far the remnant is silent. A few researchers speculate that some of the innermost matter fell back into the heart of the blast, adding enough mass to tip the scales toward a black hole. However, a thick shroud of debris at the remnant's center may hide the mystery object for decades. Unless they spot a telltale blip from the core, few astronomers plan to devote much time to that quest for now.

Instead, the shock wave and its violent impact are today's supernova growth industry. "This will keep astronomers busy for centuries," says Stephen Lawrence of Hofstra University in Hempstead, New York. By that time, an even closer supernova may bare its secrets to the orbiting telescopes in Earth's future.

–ROBERT IRION