A cometary globule shows its true color

Breaking up is *not* hard to do — at least not if you're a tiny interstellar cloud constantly pounded by radiation from hot, nearby stars. For the first time, astronomers have captured a color image of such a faint cloud, caught in the act of coming apart.

This Milky Way resident, called a cometary globule because it sports a comet-like tail of gas and dust dragged out by the bombardment of starlight, lies about 100 light-years from Earth. And in reflecting light from nearby stars, it exhibits a variety of colors that reveal much about its own composition as well as the influence of its surroundings, says David Malin of the Anglo-Australian Observatory in Epping, Australia.

Malin became interested in a cometary globule called CG4 when photographs taken with the United Kingdom Schmidt Telescope in Epping showed that the object appeared dramatically different depending on whether it was viewed through a red or a blue filter. This suggested that CG4 might display an unusual array of colors. Images taken by Malin late last year with color filters at the 3.9-meter Anglo-Australian Telescope in Coonabarabran confirmed that hunch, he says.

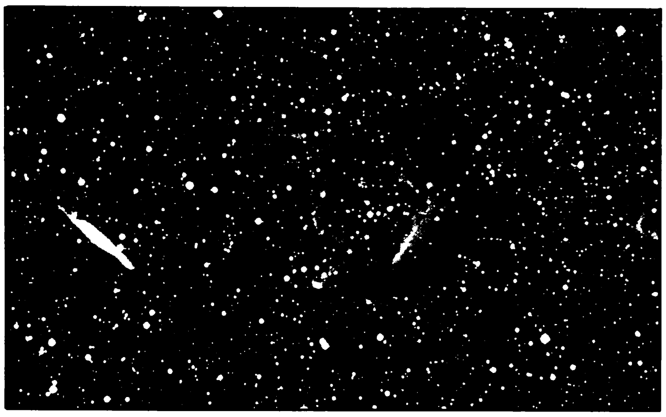
Malin reported his results this week at a meeting of the Royal Astronomical Society in Durham, England.

Unlike the majority of interstellar clouds, which serve as nurseries for new stars and measure some 10 to 30 light-years across, most cometary globules span only about one-tenth that distance and lack sufficient gas and dust to form stars. The globules become visible when background stars lie near enough to illuminate them. Each color reflected by the clouds — pale hues of red, blue and green — tells a separate story.

For instance, the blue coloring of CG4's tail indicates the presence of tiny dust particles — less than a millionth of a meter in diameter — that scatter blue light preferentially, Malin says.

The faint red glow near the center of CG4 reveals a violent, two-step process that over millions of years contributes to the total destruction of the cloud, he adds. Radiation from nearby stars heats up molecular bonds in the cloud, breaking them apart and liberating atomic hydrogen. The radiation is so intense, it also ionizes the released hydrogen, producing the red glow. While astronomers had conjectured that light from surrounding stars might release hydrogen, they hadn't expected it to have enough energy to ionize it, Malin says.

He adds that the yellow-green regions of CG4 reveal red-absorbing dust particles that lie between the cloud and Earth.



Malin

First true-color portrait of a cometary globule, a type of interstellar cloud named for its comet-like tail. This faint Milky Way object, dubbed CG4, basks in the light of nearby stars. At left lies a distant spiral galaxy.

Malin constructed the color image from three black-and-white negatives of CG4 taken through different filters. Because the cloud, which lies in the southern constellation Puppis, extends some 20 arc-minutes across the sky, he chose large-format photographic plates — 25 centimeters to a side — to make the images. In contrast, the solid-state light detectors known as charged-coupled devices are about the size of a postage stamp and cannot easily record faint, extended objects, he notes.

Millions of years from now, says Malin, after neighboring stars have died and the contents of CG4 have completely dispersed, some of its molecules may come together again elsewhere in the galaxy, perhaps to start anew as yet another interstellar cloud. — *R. Cowen*

Computer envisions bio-inspired catalysts

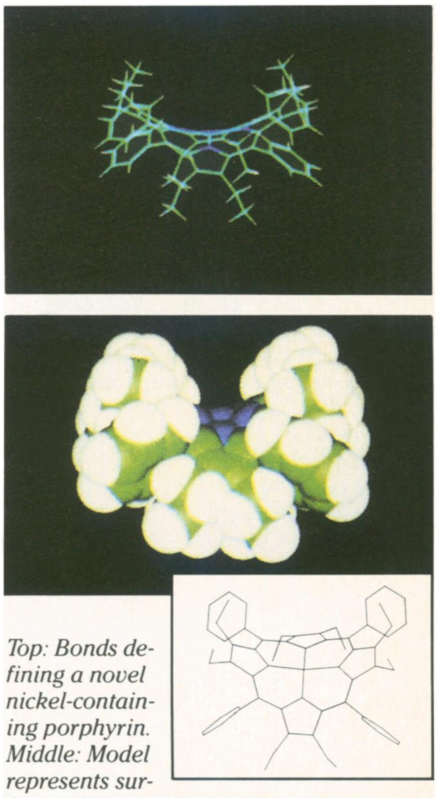
In their search for ever better industrial catalysts, researchers increasingly seek inspiration from Mother Nature. By studying how enzymes selectively foster and control important chemical reactions, catalyst designers hope to one day mimic catalytic function with far simpler and more rugged materials.

This week, scientists at Sandia National Laboratories in Albuquerque, N.M., reported a major milestone along the road to such materials: the ability to predict reliably the precise, three-dimensional shape of theoretical and potentially desirable biologically inspired catalysts.

Catalysts do not actively participate in chemical reactions; instead they offer a temporary docking site for one or more specific compounds. The more precisely a catalyst's pocket-like docking site matches the shape of a desired guest molecule, the more likely such intended molecules will dock and react.

Pharmaceutical chemists have long designed drugs to fit into specific pocket-like sites on selected proteins. "We turned that idea around," says physicist John A. Shelnutt, who leads Sandia's catalyst-design effort. "As far as I know, we're the only people who are using molecular modeling to design catalysts with pockets that fit given target molecules."

At the American Chemical Society's national meeting in San Francisco, Shelnutt delivered a series of papers on his team's work with metalloporphyrins, a class of compounds that serve as the catalytic centers for cytochrome P-450 proteins. These proteins play an important metabolic role in nearly all cells.



Shelnutt

Top: Bonds defining a novel nickel-containing porphyrin. Middle: Model represents surfaces of the porphyrin's atoms. Bottom: Dark lines depict computer prediction of same porphyrin's copper version superimposed on the actual structure (light lines), determined by X-ray crystallography.

From their study of existing porphyrins, the researchers gleaned a series of rules that characterizes how combinations of atoms in this family of molecules typically bend, stretch or become rigid in response to their internal associations — bonds, repellencies and long-distance, unbonded attractions. They then fed these "force field parameters" into a computer and instructed it to apply this code of conduct to the novel structures they began designing.

Once the team defined a new porphyrin's composition, the computer predicted the hypothetical molecule's preferred configuration. Normally, a porphyrin is flat. But these predictions indicated that as the scientists began replacing hydrogen atoms at the periphery of the molecule with relatively large and bulky subgroups — such as phenyl rings — the entire structure would ruffle. Some versions contorted so severely that a deep pocket formed around the metal atom at the center of the catalyst.

One catalyst formed a pocket "just the right size to hold carbon dioxide — and not something else," notes Shelnutt. By altering electric charges on the pocket's lining, "We can switch the catalyst's potential affinity from carbon dioxide to other small molecules like methane."

How good were those predictions? Shelnutt collaborated with Kevin M. Smith at the University of California, Davis, to synthesize samples of his newly designed porphyrins. X-ray crystallography and Raman spectroscopy have just confirmed that the actual compounds match his predictions. Indeed, Shelnutt's predicted structures are "embarrassingly accurate," says Sandia chemist Alan P. Sylwester — so close, he jokes, that they look as if they were traced from structural diagrams of the synthesized compound.

Shelnutt's team will continue working toward catalysts that might make something useful out of some of the uncontrolled carbon dioxide that poses a serious threat of global warming. The researchers are also designing a solar-driven process to detoxify chemically contaminated water. In preliminary tests, another novel porphyrin catalyst appears more than 100 times faster than the titanium-dioxide catalyst currently used in a similar solar decontamination system now under development. *— J. Raloff*

Neandertals to investigators: Can we talk?

European Neandertals, who lived from about 130,000 to 35,000 years ago, possessed all the anatomical tools needed for speaking as modern humans do, according to a report presented at the annual meeting of the American Association of Physical Anthropologists in Las Vegas last week.

The new analysis of Neandertal and modern human skulls, conducted by David W. Frayer of the University of Kansas in Lawrence, enters a debate over Neandertal vocal capacities that began in the 1970s. Arguments intensified recently with the discovery of a small neck bone said by its discoverers to demonstrate a fully modern facility for speech among Neandertals (SN: 7/8/89, p.24).

"Neandertal speech and language ability was equivalent to ours," Frayer maintains. "Whether they indeed did speak is another issue."

Frayer studied the degree of bend in the base, or basicranium, of Neandertal and modern human skulls. A flat basicranium — ubiquitous in nonhuman animals — indicates that the larynx, or voice box, sits high in the neck. An arched cranial base signifies a lower larynx and a vocal tract capable of producing the sounds of modern human speech.

Often, important features of the basicranium are poorly preserved on ancient fossils. In his study, Frayer relied on a measurement of the angle from a relatively easily determined point near the center of the basicranium to a point at the front of the upper jaw.

The extent of basicranial flattening in four European Neandertal specimens falls within the range observed in a sample of modern human skulls dating from 25,000 years ago to medieval times, Frayer contends. In fact, some of the older modern skulls display flatter skull bases than the Neandertals, he says. The evidence supports theories of a close evolutionary link between Neandertals and modern humans, he adds.

One of the Neandertal skulls studied by Frayer was reconstructed in 1989 by a French anthropologist who also argued that the angle of its basicranium falls within the range of modern humans.

Other researchers, led by anatomist Jeffrey T. Laitman of Mount Sinai School of Medicine in New York City and linguist Philip Lieberman of Brown University in Providence, R.I., discern a flatter cranial base and more restricted speech ability in European Neandertals than in modern humans. Laitman's group estimates the position of several anatomical markers on fossils to determine four basicranial angles from the back of the head to the jaw; Lieberman devised a computer model of the Neandertal vocal tract based on the skull that was later reconfigured by the French investigator.

Although Neandertals had the ability to vocalize, their speech quality fell short of that exhibited by modern humans, Laitman asserted at the Las Vegas meeting. "I'd advise caution in measuring only one angle on the basicranium, as Frayer did," he says.

Frayer cites the poor preservation of basicranial features as the prime reason for using his study method. "I'm uncomfortable with how much of the cranial base is missing on Neandertal specimens," he remarks. *— B. Bower*

Gene determines when cells live or die

When an amphibian makes the leap from tadpole to toad, the cells in its tail kill themselves because they're no longer needed. Biologists call this phenomenon programmed cell death, or apoptosis. It's a normal part of animal development, but no one knows how it works.

Now, researchers studying roundworms have uncovered a clue to the mystery. A cell's fate, they find, teeters on a single gene that keeps the built-in suicide program from starting up.

"The observation that lots of cells in the animal need something in them to continuously protect them from dying is very intriguing. It's the first time it's ever been shown that such a thing could exist," says molecular biologist Ronald E. Ellis of the University of Wisconsin-Madison.

Working at the Howard Hughes Medical Institute at the Massachusetts Institute of Technology in Cambridge, Ellis and his colleagues studied the roundworm *Caenorhabditis elegans* and found that a gene called ced-9 acts as a switch to regulate programmed cell death. In *C. elegans* mutants with the ced-9 gene turned on, cells that normally would have died during the animal's development survived instead. Conversely, in roundworms with a mutation that turned off the gene, cells that normally would have lived committed suicide, the researchers report in the April 9 NATURE.

With ced-9 turned off, "cells that were supposed to survive and become neurons or muscles or some other kind of cell were killing themselves," says Ellis. "The animals eventually died."

Although the exact mechanism underlying this process remains unclear, ced-9 appears to control two other genes, ced-3 and ced-4, previously found to direct a roundworm cell's suicide process. Ellis and his co-workers discovered that ced-9 had no effect in mutant roundworms lacking these two genes. "The switch doesn't matter if there's no machine at the other end," Ellis explains.

While *C. elegans* consists of a mere 1,090 cells, biologists believe that studies of programmed cell death in this simple model will help them understand how the process works in more complicated animals, including humans. In fact, ced-9 seems to parallel a gene called bcl-2, which controls the suicidal tendencies of B- and T-cells in the human immune system, says Stanley J. Korsmeyer of the Washington University School of Medicine in St. Louis, who studies apoptosis in humans.

"Bcl-2 has implications for how ced-9 may act," Korsmeyer says, "while ced-9 has implications for the regulation of cell death in mammals." *— M. Stroh*