condoms and vaginal virucides, could arguably have a far greater impact on curbing HIV transmission than candidate vaccines.

Nonetheless, I applaud Cohen's impassioned plea for a sustained, coherent HIV-vaccine program. On the book's dust jacket, Bill Gates and Seth Berkley, the president of the International AIDS Vaccine Initiative, do the same. Berkley's organization now has the budget to realize Cohen's vision. Let us hope that its leadership reads *Shots in the Dark* attentively. While Cohen decries the tortoise-pace of government bureaucracy and academic peer review, he also warns more subtly of the dangers of egotism and cronyism that can all too easily encroach on a wealthy nongovernmental organization.

BOOKS: COSMOCHEMISTRY

We Are Made of Starstuff

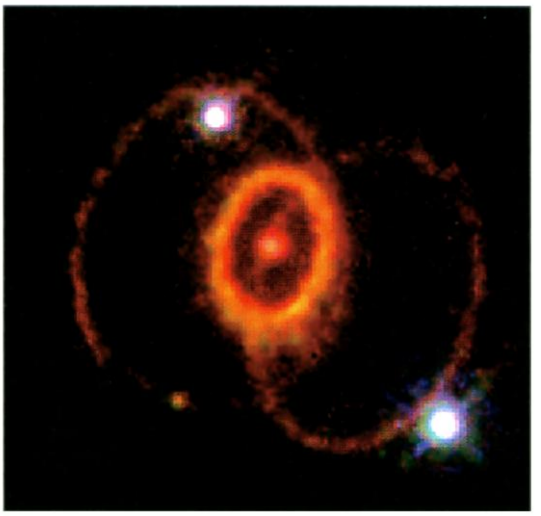
Craig J. Hogan

Marcus Chown's *The Magic Furnace* tells the story of how we came to understand first that the world is made of atoms and then how those atoms were made in the universe. It's an inspiring tale that bears retelling well, especially when famous anecdotes are freshened up with intriguing details. Did you know that Mendeleev was a bigamist and crossed swords with Tolstoy? and that he happened on the periodic table while he was using cards to organize information for a textbook? Or that Marie Curie's lab notebooks, still too radioactive to handle safely, are kept in lead-lined boxes? Emissions from her fingerprints still leave a record on photographic film inserted between the pages.

Chowan, a science writer and *New Scientist*'s cosmology consultant, revels in these sometimes heroic, sometimes melancholy or ironic, scenes from a romantic period of science: a handful of smart and curious people working on the ragged edge of academia, often in isolation or on borrowed time, who stumble around with good and bad hunches and make the best of their limited tools. The reader feels drawn into the way these scientists lived and worked, and into the way they thought about the problems they were solving. People whose names are known to scientists mainly for their important discoveries take on dimensions of real human beings. The orphaned and impoverished lens technician Josef von Fraunhofer is one example: After his fortunes were transformed by an industrial accident, he worked to calibrate the refraction of various glasses. In doing so, he eventually discovered the lines in the solar spectrum, which led to modern astrophysics.

Although Chown offers nonspecialists a fine modern account of the foundations of cosmochemistry, *The Magic Furnace* doesn't follow everything through to the state of the art. Readers won't find out that there are two fundamentally different types of supernovae, one powered like a thermonuclear bomb and leaving no remnant, the other powered by the gravitational energy of a forming neutron star. The author doesn't discuss how Standard Model physics now informs us about the interior structure of the quarks and gluons (which make up neutrons and protons) and about the formation by subtle neutrino effects of neutron-rich ("r-process") nuclei in supernovae. He doesn't mention that we now directly image giant sound waves oscillating in the primordial gas, waves whose properties confirm in detail many aspects of Big Bang cosmology; nor does he explain that we monitor oscillations of the solar plasma, which confirm knowledge of its deep interior. Perhaps there are now just too many threads to weave them all together into a really compelling story. Certainly, the picture is not as romantic as it used to be.

The Magic Furnace
The Search for the Origins of Atoms
by Marcus Chown
Oxford University Press, New York, 2001. 240 pp. $25. ISBN 0-19-514305-1.



Creative detonation. Rings of glowing gas encircle the site of supernova 1987A in the Large Magellanic Cloud. Supernovae produce heavy elements and scatter them into space.

Consider that irresistible, between-your-eyes starstuff idea: that your own "atoms of curiosity" come from the stars—a koan for the age of science that focuses thought on one's relationship with reality. I think even this sense of amazement has changed with the times.

One step in that change occurred when Fred Hoyle connected the idea of starstuff with what Chown calls "the most outrageous prediction in science." Hoyle calculated that stars can only make carbon, and hence humans could only exist, if the carbon nucleus has a resonance with a particular energy (7.65 MeV) that enhances the rate at which beryllium-8 nuclei capture helium nuclei at the prevailing temperatures inside stars. Willy Fowler subsequently confirmed that this resonance indeed exists; in Chown's words, "To this day, Hoyle is the only person to have made a successful prediction from an anthropic argument in advance of an experiment."

Although this remains a favorite story of we cosmologists, from a modern perspective the anthropic aspect of Hoyle's prediction seems less mysterious than it once did. Currently, we believe we know all the underlying equations that are important for the structure of nuclei, even if we can't compute everything that they predict and don't know what fixes the parameters or seemingly arbitrary coefficients that appear in them. It should not really be surprising that a resonance exists in carbon-12 somewhere close to the combined energy of beryllium-8 and helium-4; in the spirit of quantum mechanics, the carbon nucleus in this excited state can be regarded as a mixture of the two other nuclei. That is the mathematical nature of the resonance. The energy levels would agree approximately even if you fiddled with the parameters of the underlying forces that determine the structure of the nuclei, for about the same reason that some of the energy levels of atomic and molecular hydrogen approximately coincide. Also, getting the production rate of carbon right may not require very precise fine tuning of the resonance, because the structure of stars includes a built-in thermostat that automatically adjusts the temperature to just the value needed to make the reaction go at the correct rate. This is why stars remain stable for millions of years. Although Hoyle's insight was an intellectual triumph of theoretical astrophysics, it doesn't necessarily follow that the nature of physics is tuned by humanity's carbon production requirements.

It is, however, undeniable and astonishing that starting from a formless hot gas, atoms have developed a sense of their own history. Chown's book offers readers and their inner atoms an enjoyable introduction to that history.

The author is in the Astronomy Department, University of Washington, Box 351580, Seattle, WA 98195–1580, USA.