was trying to blow his house down.

What Ayares was praising, and what Representative James Sensenbrenner (R–WI) was criticizing, was the Advanced Technology Program (ATP) run by the National Institute of Standards and Technology (NIST). Created by a 1988 law aimed at making U.S. companies more competitive in global markets by funding innovative research with potentially high payoffs, ATP for the last decade has been a $1.5 billion political litmus test for whether the government should subsidize corporate research. A hard-earned truce in recent years has left ATP with an annual budget of about $200 million, far below what the Clinton Administration has requested in most years but much more than many Republicans say it deserves.

Last week Sensenbrenner, chair of the House Science Committee, tried to shatter that truce by releasing a report (GAO/RCED-00-114) questioning ATP's ability to plow new ground. ATP is violating its mission by backing projects that "addressed similar research goals to those already being funded by the private sector," the Government Accounting Office (GAO) concluded after examining three ATP awards. Although the auditors concede that company scientists pursued "unique technological approaches" in carrying out the funded work, Sensenbrenner complained in a press release that ATP was "duplicating private research and shortchanging taxpayers."

ATP supporters say that the report's methodology and conclusions are badly flawed. NIST Director Ray Kammer says its definition of "similar research" is so broad that "by that doubtful criterion we would shut down federal research on cures for a host of diseases" and many nonmedical projects. One participant in last week's academy meeting saw the report as old wine in new bottles: "It's part of a continuing battle by those who dislike ATP."

For Ayares, PPL's vice president for research, the idea that his ATP grant is duplicative ignores both the formidable technological challenges his pig xenograft team faced and the fact that the company was ready to jettison the project. "We were going down," Ayares told his audience. The company laid off a third of its research staff in Blacksburg, Virginia, and shut down complementary projects there involving cows and rabbits. Ayares could read the writing on the wall: "My house was on the market," he confesses.

Instead, 5 months after receiving the grant, the company announced the Caesarian birth of five piglets cloned from adult cells. Big Pharma companies and venture capitalists that had once shunned the work as too speculative are now calling him on the phone and begging him to do a deal, Ayares says. The company's board of directors "now agrees to support us for as long as it takes" to find support for clinical trials and commercialization of the technology, he crows. "Without ATP," he says, "there would be no cloned pigs, only 4 years of intellectual property."

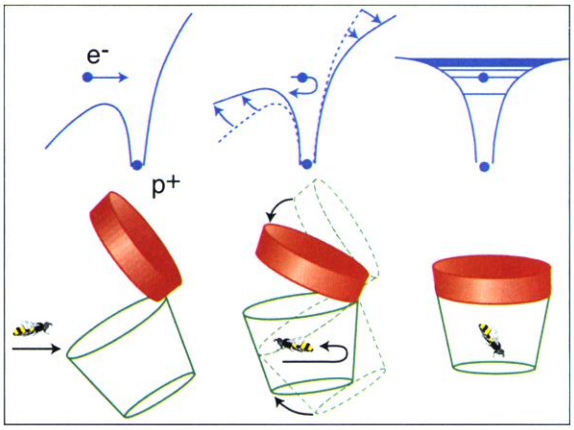
–JEFFREY MERVIS

ANTIMATTER

Coaxing Shy Particles Into an Atomic Jar

One major frustration the universe inflicts on physicists is a serious shortage of antimatter. It should be fascinating stuff—looking-glass atoms with negatively charged nuclei surrounded by clouds of positive charge, and with who knows what bizarre properties—but no one has ever made enough of it to tell.

That could change, thanks to a new method a Dutch-American team has demonstrated for recombining free electrons with ions to form atoms. In the 24 April *Physical Review Letters*, researchers led by Bart Noordam of the FOM Institute for Atomic and Molecular Physics (AMOLF) in Amsterdam describe how they enabled rubidium ions to trap electrons by applying a pulsed electric field in a series of steps similar to the way a child traps an insect in a jar. The team claims the technique can be used to produce atoms of antihydrogen, the simplest form of antimatter, in greater numbers than ever before.



Atom trap. Like a child catching a wasp, shifting electric fields stop a speeding electron, then block its escape.

"So far there is no proven way to make these atoms, so any additional suggestion is certainly welcome," says Theodor Hänsch of the Max Planck Institute for Quantum Optics in Garching, Germany. Thomas Gallagher of the University of Virginia in Charlottesville agrees wholeheartedly. "A few years ago, I would have thought this is completely nuts," he says. "I think it is a nifty trick."

To create antihydrogen, scientists must nudge a positron—the antiparticle of an electron—into a quantum-mechanical dance around a negatively charged antiproton. Between 1995 and 1997, physicists at CERN, the European particle physics laboratory near Geneva, and at the Fermi National Accelerator Laboratory near Chicago forged 108 atoms of antihydrogen in particle accelerators, but all perished in collisions with accelerator walls within billionths of a second. Because of the short life-span, Noordam says, "this was not a method that ever could lead to antimatter that we actually could study."

Researchers tried to extend the longevity of antihydrogen by catching it in Penning traps, devices that slow down and confine atomic particles through an interplay of electric and magnetic fields. In 1996, physicists at CERN tried bringing together antiprotons and positrons in such a trap, but the energetic positrons just flew past the antiprotons without forming atoms. "You can compare this to the flyby of a spacecraft around a planet," Noordam says. If the spacecraft is moving too fast, it will swerve past the planet and out into space. To put it into orbit, you must first reduce its energy.

Scientists are investigating several braking maneuvers for a positron approaching an antiproton. Hänsch and colleagues plan to use laser light to stimulate the positron to emit a photon, jettisoning enough energy for the antiproton to capture it. Another team, led by Gerald Gabrielse at Harvard University, is investigating a method called three-body recombination, in which the positron transfers some of its energy to another, onlooking positron. Researchers plan to test those methods and others when CERN's new Antiproton Decelerator becomes available for experiments later this year, but the yield of antiatoms is still expected to be very small.

Noordam and Kees Wesdorp at AMOLF think their new technique can do much better. As stand-ins for positrons and antiprotons, they shoot electrons into tiny clouds of rubidium ions. The speeding electrons swerve toward the oppositely charged rubidium ions. Before the electrons can swing past the ions and escape, an electric field decelerates them and turns them back. Then, suddenly, the field is switched off, leaving some of the stalled electrons easy prey for the rubidium ions to capture into wide orbits. Researchers compare the method to the way a child coaxes a wasp into a jar, then clamps on the lid just as the wasp turns around to escape.

The AMOLF team obtained three atoms for every 1000 free ions, more than 100 times better than other methods, Noordam says. "This is very efficient, and this is impressive," says Hänsch's collaborator, Joachim Walz.

SOURCE: FOM/AMOLF

Next, the Dutch experimenters plan to replace the rubidium ions with hydrogen nuclei—protons. Theoretical calculations show that the capture step should work just as well for hydrogen as it does for rubidium, says another team member, theoretical physicist Francis Robicheaux of Auburn University in Auburn, Alabama. If all goes well, next year the team hopes to apply the technique at CERN to create antimatter.

Abundant antiatoms would certainly give physicists much to think about. For example, general relativity holds that an atom and its antimatter counterpart should have identical masses, but some versions of string theory disagree. Serious discrepancies between predictions and observations could revolutionize theories of matter. "If you want to discover something interesting and unusual," Gabrielse says, "you have to look at unusual places."

–ALEXANDER HELLEMANS

Alexander Hellemans writes from Naples, Italy.

EVOLUTION

Stretching the Reign Of Early Animals

To paleontologists, fossils are crucial, but so is time. Fossils tell the who of evolution, but for the how and why, paleontologists need to put together a story in which events occur in the right order and unfold at a realistic pace. Nowhere is that task more demanding than in the murky realm of the Ediacara, frond- or disc-shaped blobs of living matter that preceded the more familiar (if still bizarre) creatures of the Cambrian explosion 543 million years ago. Cryptic Ediacaran fossils are hard enough to connect to later animals, but ordering them in time has been if anything harder. Groping for firm dates, paleontologists had been forced to rely on wiggles in the changing isotopic composition of the rock encasing Ediacara.

No more. On page 841 of this issue of *Science*, geochronologist Mark Martin of the Massachusetts Institute of Technology and his colleagues report that they have determined the age of the most diverse Ediacaran fauna through highly precise uranium-lead radiometric dating of a layer of volcanic ash. The technique—which overthrows isotopic wiggle counting as the best means of keeping Ediacaran time—has produced a surprisingly early date. It not only doubles the length of the late Ediacaran reign but also revises a strange and mysterious chapter in the early history of life.

The oldest, simplest Ediacara are found in the Mackenzie Mountains of northwest Canada in rocks thought to be about 600 million years old, but the most diverse and complex Ediacara seemed to come 50 million years later. That's right in a narrow window of time—the last 6 million years before the Neoproterozoic era gave way to the evolutionary commotion of the Cambrian—when complex, mobile organisms, including perhaps the last common ancestor of modern multicellular life, emerged.

For all their tantalizing significance, though, the Ediacaran layers offer few distinctive fossils to serve as bookmarks in the geologic record. Instead, for more than 5 years researchers have pegged their geologic calendars to the ratio of two isotopes of carbon. The ratio changes with shifting environmental conditions, such as ice ages and varying biological productivity.

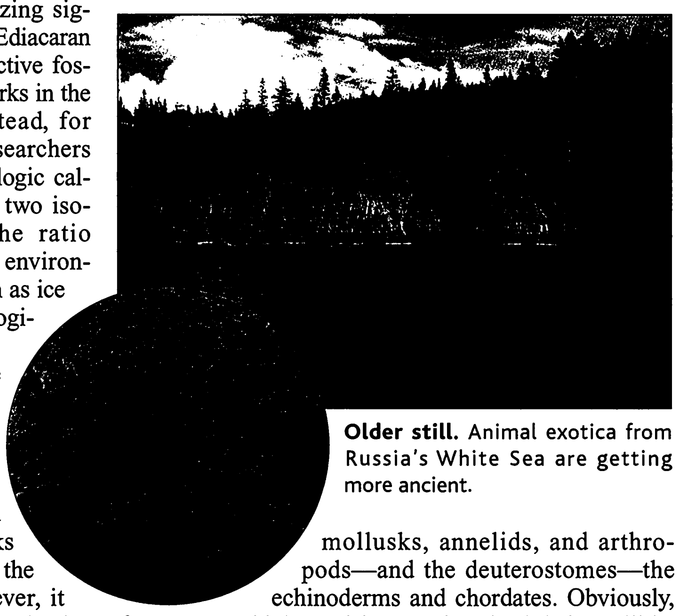
On either side of the late Neoproterozoic flowering, the carbon-isotope ratio rises and falls in roller coaster–like spikes and troughs. In some rocks from the latest part of the Neoproterozoic, however, it appears to level off around values of +1 to +2 per mil. Taking the coincidence at face value, paleontologists tried assuming that all of the most diverse deposits of Ediacara—even those lacking carbon ratios, such as the original find in the Flinders Ranges of South Australia—were the same age as those of the "+2 plateau." It seemed to work.

Now a volcanic ash bed has blown that tidy assumption sky-high. Martin and his colleagues found the bed in the Ediacara-bearing cliffs along the coast of the White Sea, 100 kilometers northwest of Arkhangelsk and 1100 kilometers north of Moscow. Once an ash bed is found—and more and more are turning up as geochronologists join paleontologists in the hunt—the key is separating out the mineral zircon. By measuring the amount of lead produced in zircon grains through the steady radioactive decay of uranium, geochronologists can determine the age of zircon formed in the Neoproterozoic with a precision of better than 1 million years. Extracted and analyzed, the White Sea zircons yielded an age of 555.3 ± 0.3 million years.

"The date is exciting," says paleontologist Guy Narbonne of Queen's University in Kingston, Ontario. "It's nearly 10 million years older than we might have expected for the Flinders, Australia, Ediacara, yet [the two Ediacaran faunas] are indistinguishable" in diversity and complexity. Apparently, the assumption paleontologists had drawn from the carbon isotopes—that the most diverse Ediacaran fossils have similar ages—does not always hold, says Narbonne.

This first absolute date among the most diverse Ediacara changes the history of life by pushing back the emergence of large, complex organisms. One of those creatures may have been the long-sought animal whose descendants split into the two great lineages of modern life: the protostomes—mollusks, annelids, and arthropods—and the deuterostomes—the echinoderms and chordates. Obviously, "high-precision uranium-lead dating will be extremely critical in sorting out Neoproterozoic evolution," says Narbonne. Keep an eye peeled, paleontologists.

–RICHARD A. KERR

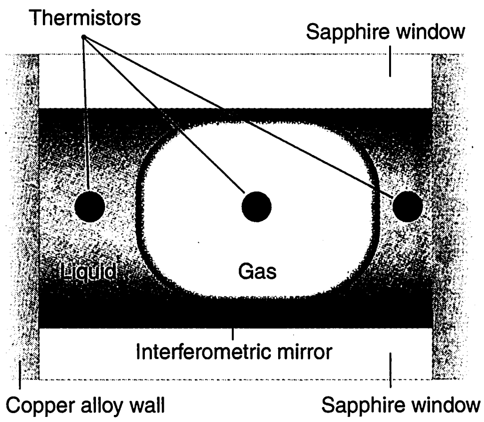


Older still. Animal exotica from Russia's White Sea are getting more ancient.

THERMODYNAMICS

Backward Heat Flow Bends the Law a Bit

When the teachers go on strike during an episode of *The Simpsons*, the 8-year-old overachiever Lisa burns up her excess energy by creating a perpetual motion machine. Her father, Homer, is furious. "In this house," he barks, "we obey the laws of thermodynamics!" Most houses do. But now a space-borne experiment has for the first time accomplished what the second law of



Topsy-turvy. In a sealed cell, thermistors showed that fluid drew heat from cooler walls.

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