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—

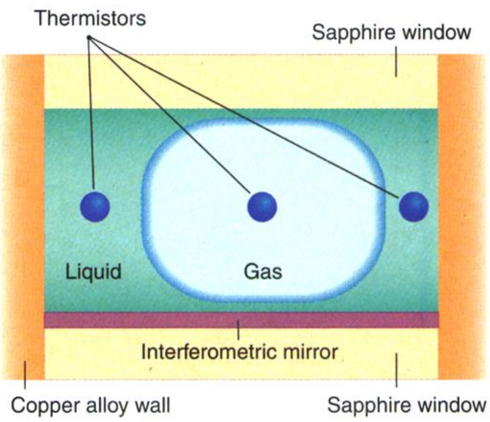
Older still. Animal exotica from Russia's White Sea are getting more ancient.

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

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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