cues," says neuroscientist Mel Goodale, of the University of Western Ontario, in London. But perhaps the most intriguing aspect of the work, he says, is that the Caltech team found neurons sensitive to object distance, not in the "where" stream, where conventional wisdom suggested it to be, but in primary visual cortex and in V4, which is part of a second processing stream, the "what" stream, which specializes in the identity of objects. This could mean the trait may occur throughout that stream, and perhaps the whole visual cortex.

This invites researchers to "rethink the 'what' pathway" and the role distance information plays in its mission, says Sejnowski. Size is relevant to an object's identity, he says, and the "what" stream would need distance information to compute size. "In retrospect," says Desimone, "it makes perfect sense" that visual maps in the 'what' stream would be three-dimensional. "But honestly," he adds, "I was surprised."

–MARCIA BARINAGA

PHYSICS

First Ticks of a Super Atom Clock

Bose-Einstein condensates have yet to make the leap from quantum toy to tool. But in prodding these curious aggregates of supercold atoms, physicists have elicited some hints of future practicality. Now, a group led by Carl Wieman at JILA and the University of Colorado in Boulder has fashioned a crude clock based on the quantum ticks of these balls of atoms. A much-refined version might one day replace the traditional atomic clocks that keep the world on time.

Today's atomic clocks are pegged to the frequency of light emitted when a cesium atom flips between two slightly different configurations—one in which the spin of the electron and the nucleus point in the same direction, and one in which they point in opposite directions. To get an observable signal, clocks usually watch millions of atoms. With such large numbers, however, the atoms interfere with each other electrically, smearing out and shifting the precise spacing of atomic levels, which blurs the regular ticking.

Condensates offer a way to get more bang for the atom. A condensate forms when a cloud of atoms is cooled to within a hair of absolute zero and all the atoms leap into the same quantum state "like lemmings," Wieman says. Then, it turns out, instead of acting like individual clocks, their pendula swing in perfect harmony, which can amplify the signal manyfold. "That's a huge difference," says physicist Steven Chu of Stanford University.

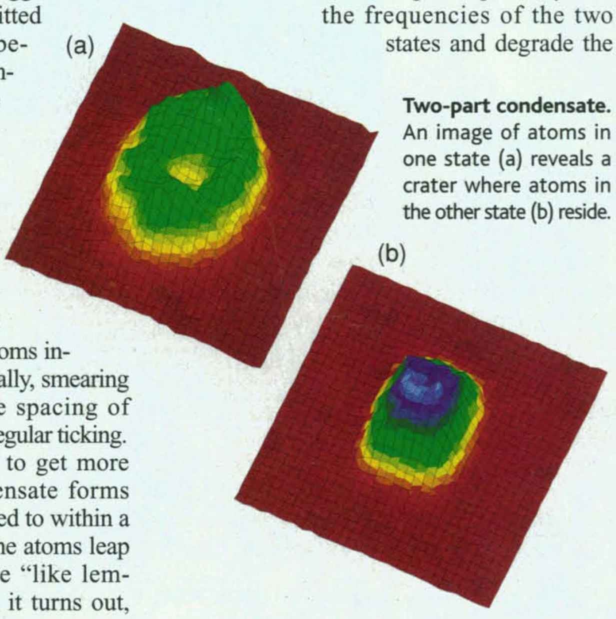
Wieman and colleagues didn't set out to make a condensate clock. Condensates, like all quantum objects, have wavelike properties, and the team was studying how the waves of two condensates interact over time. They confined a few hundred thousand rubidium atoms in a magnetic trap and cooled them into a condensate. Then they split it using a radio frequency burst to form a second, overlapping condensate, in a different spin state from the first.

The quantum waves corresponding to the two states have frequencies that differ by a small but precise amount, just like the two states of cesium that have been used to keep time. The frequency difference can be inferred by allowing the two condensates to interact briefly and watching how many atoms jump from one to the other. The team expected that as the condensates sloshed around in the trap, the frequency difference would get washed out. But when they measured the populations of the condensates with a laser, they found that the frequency difference was durable enough to keep time.

"You can think of this as the first Bose-Einstein condensate clock," Wieman says. But he cautions, "I wouldn't want to push the accuracy [of] it much." Jason Ensher, a member of the team, notes that it is only good to about a billionth of a second—over a million times less accurate than the best atomic clocks.

Another practical limitation of this version is that the laser burst that reads the time destroys the clock. And the magnetic fields of the trap will probably blur the frequencies of the two states and degrade the precision of such a clock, points out Christopher Oates, a physicist at the National Institute of Standards and Technology in Boulder. Condensate clocks may keep time for future generations, he says, but for now the idea is "still in diapers."

–DAVID KESTENBAUM



Two-part condensate. An image of atoms in one state (a) reveals a crater where atoms in the other state (b) reside.

HALL ET AL.

ENTOMOLOGY

Earth's Unbounded Beetlemania Explained

It's a tale every evolutionary biologist knows by heart: Asked what he had concluded about the Creator from studying creation, the great biologist J. B. S. Haldane reputedly quipped that the Creator "had an inordinate fondness for beetles." And indeed, the 330,000-odd species in the order Coleoptera—the beetles—far exceed the number in any other plant or animal group. "It's a saying that's always in the back of your mind," says Brian D. Farrell, an evolutionary entomologist at Harvard University. On page 555, Farrell hands the credit for this diversity to the beetles' own fondness for a leafy diet.

Laying siege. Willow-eating *Chrysomela*, laying eggs, profited from rise of flowering plants.

DAVID DUSSOURD

Although the Coleoptera arose some 250 million years ago, "age alone doesn't explain" their diversity, says Farrell. Instead, his research shows that the appearance of flowering plants some 100 million years ago set leaf-eating beetles on speciation's fast track. "It's a classic case of coevolution," says Farrell. "The plants were like a new, unoccupied island, and the herbivorous beetles were among their first colonizers—that's what opened the door for their dramatic radiation."

To reach that conclusion, Farrell merged paleontology, phylogenetics, biogeography, and plain old natural history. "This kind of analysis is what evolutionary biology is all about," says Harvard's E. O. Wilson. "He's addressed two of the most important problems in the field: what determines the number of species [in each taxon] and why some groups, like the leaf-eating beetles, are just over the top in terms of success." Adds