one-quarter of Antarctica. In 1981, University of Maine glaciologist Terence Hughes dubbed Pine Island Glacier and the adjacent Thwaites Glacier the "soft underbelly" of the ice sheet because they seemed particularly vulnerable in warm climates like today's. They lack the extensive floating ice shelves thought to buttress other glaciers that are draining the ice sheet, he noted. They are also exposed to the relatively warm South Pacific Ocean.

Once these vulnerable ice streams began to give way, Hughes speculated, the generally downward slope of the seabed that the ice sheet rests on would accelerate the grounding line's retreat and the accompanying thinning of the ice, ultimately leading to the complete collapse of the ice sheet within a couple of centuries. The result would be a sea level rise of more than 5 meters—enough "to back up every sewer in New York City," as one researcher puts it, not to mention flood any low-lying coast, from all of South Florida to the city of Bangkok.

Rignot looked for early signs of collapse in observations of the 33-kilometer-wide Pine Island Glacier made between 1992 and 1996 by the radars aboard the European Earth Remote Sensing satellites ERS-1 and ERS-2. In his computer analysis, he allowed radar signals reflected from the glacier during satellite passes a few days apart to interfere with each other. The resulting interference pattern, sensitive to small vertical motions, revealed the subtle flapping of the floating ice as ocean tides raised and lowered it. The grounding line at the hinge of the flapping ice shelf retreated into the ice sheet at a rate of 1.2 ± 0.3 kilometers per year during the 4-year period, Rignot concluded. "That's a significant retreat," he says.

"I would say it's surprisingly large," agrees radar glaciologist Mark Fahnestock of the University of Maryland, College Park. "It could potentially lead to a collapse" of the ice sheet. But researchers aren't panicking yet. Their primary reservation, which Rignot shares, is that 4 years "is a very short interval," says Alley. "Glaciers do weird things." For example, one of the ice streams draining into the Ross Sea stopped flowing about 100 years ago, and another slowed by 50% during the past 35 years.

More radar surveillance should tell whether the glacier's retreat is continuing, and measurements of exactly how the seabed slopes beneath the glacier should indicate whether the retreat really will accelerate. "That guarantees a very high priority will be to map the sea floor in that whole area," says Hughes.

Getting to know Pine Island Glacier better will not be easy. It's "a hideous place to work," says Alley. It's so remote, "you can't get there from anywhere, and the weather stinks." But to see what the warming world might hold, glaciologists are already breaking out their cold-weather gear.

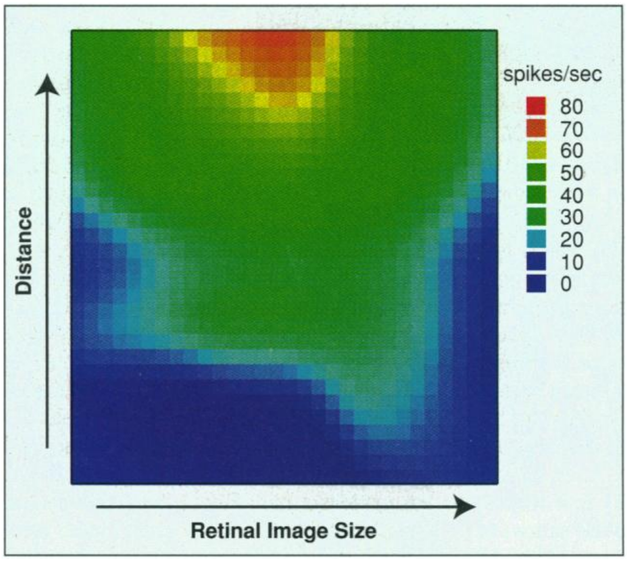
–RICHARD A. KERR

NEUROBIOLOGY

How the Brain Sees in Three Dimensions

When Renaissance painters solved the problem of depicting three-dimensional (3D) scenes on flat canvases, their paintings blossomed into realistic representations of the world. Our brain must solve this problem every day to reconstruct 3D views from images that fall on the 2D surface of our retinas. Researchers have long known that we use various cues to accomplish this, such as the stereoscopic effect of binocular vision and the relative sizes of objects. Now, a team at the California Institute of Technology in Pasadena has made a surprising discovery about the neurons that apparently translate distance cues for the brain.

Most neuroscientists thought that neurons sensitive to object distance would be located in the so-called "where" processing stream, a set of brain areas that receive information from the primary visual cortex and use it to compute spatial relationships that, among other things, guide movements, such as the reach of a hand toward an object. But on page 552, Caltech's John Allman and Allan Dobbins and their co-workers report finding brain neurons outside the "where" stream that register depth, as indicated by correlations between their firing rates and the absolute distances of objects.



Far-out. A "farness cell" responds best to a distant object that produces a midsize retinal image.

RICHARD JEO/CALTECH

"This paper is going to attract a lot of interest," predicts Robert Desimone, director of intramural programs at the National Institute of Mental Health. Terrence Sejnowski, a neuroscientist at the Salk Institute in La Jolla, California, agrees, noting that it suggests that depth-sensing neurons are found throughout the visual cortex, their information combining with the 2D map that already exists in each visual cortical area to provide the areas with full 3D maps of visual space.

The Caltech team identified the depth-perception neurons by recording the activity of neurons in monkeys' brains as the animals looked at bars of light displayed on a computer screen at various distances from the monkeys. The team looked in two brain areas, the primary visual cortex and a nearby area called V4, and found that some neurons in each area respond best to light bars that produce a particular size image on the retina. Because the size of the retinal image changes with the screen's distance, that means the brain's response to any bar would also change with distance—no surprise there.

But when the researchers kept the size of the retinal image constant by varying the size of the light bar as they changed the position of the screen, they still found, Allman says, that "distance was having a very powerful modulatory effect" on some neurons. There were "farness neurons" whose responses increased as the screen moved away, "nearness neurons" whose responses grew stronger when the screen moved near, and other neurons that peaked in between.

The researchers then monitored the firing rates of these neurons as they selectively removed visual cues for distance. Some neurons stopped registering distance when one eye was covered, suggesting that they depend on binocular cues. Others worked monocularly as long as the monkey had a broad view of the room and the monitor, but lost depth perception when the monkey viewed the image through a tiny hole. And some neurons continued to register distance when both context and binocularity were removed. Allman and Dobbins think those neurons may respond to cues such as the focus of the eye, which varies with distance, or the angle of gaze, which shifts inward toward the nose as an object gets nearer.

"It is interesting that different cells appear to be tuned to different kinds of depth 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.

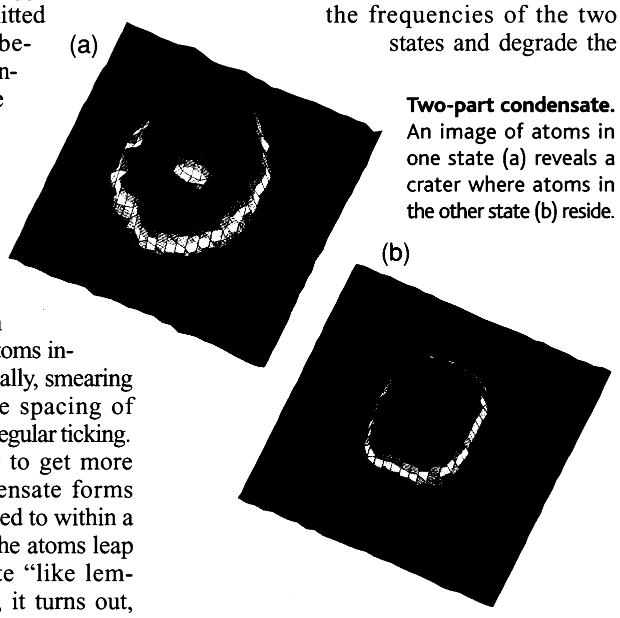
Wieman and colleagues didn't set out to make a condensate clock. Condensates, like all quantum objects, have wavelike properties, and the team was studying how the waves of two condensates interact over time. They confined a few hundred thousand rubidium atoms in a magnetic trap and cooled them into 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



HALL ET AL.

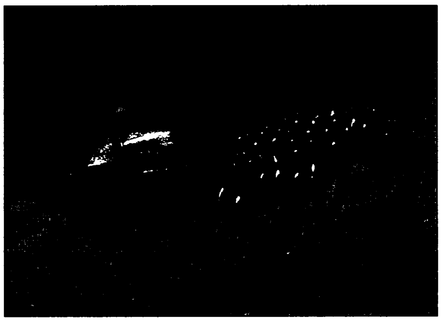
Two-part condensate. An image of atoms in one state (a) reveals a crater where atoms in the other state (b) reside.

DAVID DUSSOURD

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.

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