grams. Small's plan would also create discipline-based institutes in astrophysics, geology and earth sciences, and the life sciences. A fourth, perhaps in conservation biology, would encompass the Smithsonian's remote field sites in Panama, Florida, and Maryland. Currently, each administrative unit, be it the CRC or a museum department, operates its own research program.

With personnel details yet to be announced, the proposed closures have had a devastating effect on staff members. "Morale is just right down in the basement," says one biologist who requested anonymity. Beyond the impact on their job status, some museum researchers worry that creating disciplinary institutes could conflict with the Smithsonian's stated mission of increasing the diffusion of scientific knowledge by putting too much distance between its scientific and educational activities. –ELIZABETH PENNISI

NEUROSCIENCE

Location Neurons Do Advanced Math

A mouse's minutes are numbered if it rustles through a field within hearing distance of a barn owl. The owl knows where to aim its talons even in the dark, thanks in part to a precise map of auditory space engraved in its brain's inferior colliculus, located in the brainstem. Now researchers have discovered that space-specific neurons in this map can perform more sophisticated computations than are commonly credited to neurons: Most neurons simply add incoming signals to come up with an answer, but neurons in the owl's auditory map multiply.

Where did it go? Some barn owl neurons multiply location signals.

If a mouse squeaks to an owl's right-wing side, the owl's right ear registers a slightly louder signal, and slightly sooner, than the left ear. Earlier research by Masakazu Konishi and colleagues showed that a set of auditory neurons calculates this interaural level difference (ILD) and interaural time difference (ITD) and sends the results to neurons in the inferior colliculus that are precisely tuned to particular locations. Humans use ILD and ITD cues as well, but the human auditory map isn't as well understood as the barn owl's.

To discover how the owl's space-specific neurons process the incoming timing and level information, neuroscientists José Luis Peña and Konishi of the California Institute of Technology (Caltech) in Pasadena outfitted 14 barn owls with headphones and monitored the auditory map's responses to pairs of sounds. As they report on page 249, multiplication best describes how the neurons behave; a multiplicative model predicts how the neurons respond to different kinds of stimuli with about 98% accuracy.

"This is the cleanest evidence of multiplication in the brain," says Christof Koch, also of Caltech but not involved in the project. He points out that many neural tricks in humans as well as owls seem to require multiplication, such as keeping neurons in the visual cortex trained on one spot even when the eyes or head move. But most earlier reports of multiplicative neurons relied on "dirty multiplication," he says—some combination of addition and multiplication that wasn't as satisfying as that in this new report.

Two properties illustrate what it means for a neuron to multiply. First, when very faint ITD and ILD signals correspond to the same region of space (giving mutually affirming indications that a mouse is underneath a log off to the right, say), neurons in the inferior colliculus fire robustly. If the two subthreshold signals were added, in contrast, their combined stimulation wouldn't rile up the space-specific neurons enough to fire. Second, the lack of either an ITD or an ILD signal can veto a space-specific neuron's firing. In multiplication, $2 \times 0 = 0$; in a barn owl's inferior colliculus, a strong ITD signal × no ILD signal = no response. As Peña explains, the neuron acts like an "and" gate, requiring both signals, rather than an "or" gate, which could respond to just one.

Archetypal neurons don't compute this way. Normally, a neuron receives a host of excitatory and inhibitory signals of various volumes along its dendrites. When the signals add up to surpass some threshold, the neuron fires. Such a neuron acts like a transistor in an electronic circuit, says Koch. But a neuron with the power to multiply, he says, "is more like a little processor; computationally it's much more powerful."

Mathematically, the behavior of these space-specific neurons is easy to explain. Neurophysiologically, it's another matter. "We don't know anything about how [multiplication] is computed" in these neurons, says Koch. Peña says his and Konishi's "next step is to figure out the biophysical mechanisms that underlie" the multiplication.

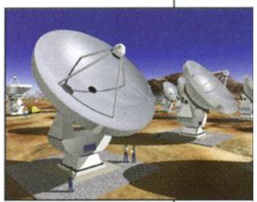
–LAURA HELMUTH

CREDITS: (TOP TO BOTTOM) ESO; J. L. PEÑA *ET AL.*

ScienceScope

ALMA Matters Astronomers' hopes of building a giant 64-dish radio telescope have taken a big international step forward. Japan last week joined North America and Europe in the consortium planning the $550 million Atacama Large Millimeter/Submillimeter Array (ALMA), planned for Chile's Atacama desert.

In the mid-1980s, astronomers in North America, Europe, and Japan independently started planning such arrays, which will probe the formation of stars and galaxies. North America and Europe officially combined their efforts in 1997. Last week's resolution means scientists from 15 countries on four continents are now working on ALMA, making it "truly a world telescope," says Norio Kaifu of Japan's National Astronomical Observatory.



The next challenge is building it. The Bush Administration has not included any construction funds in its 2002 budget request (see p. 182), although Japan's education ministry has given ALMA a green light, and Europe hopes to keep pace. If the money begins flowing by the end of 2002, scientists say ALMA could be operating by 2010.

Depressing Difference Eighth-grade students from Naperville, Illinois, a wealthy suburban district nestled between Fermilab and Argonne National Lab, learned last week that they lead their peers around the world in understanding science. Their urban counterparts 30 minutes away in Chicago city schools, however, rank with the likes of Iran and Tunisia near the bottom of the list. The results were part of an exercise in which 13 state and 14 local U.S. school districts compared themselves to 38 countries that took the Third International Mathematics and Science Study in 1999.

National educators hailed the "courage" of big-city school superintendents like Chicago's Paul Vallas to spend $75,000 on what was a predictable academic drubbing, given the socioeconomic advantages of districts like Naperville. "These results make the gap visible and therefore attackable," thundered Education Secretary Rodney Paige. Sitting next to National Science Foundation director Rita Colwell, whose agency has spent hundreds of millions of dollars in the past decade trying to improve science and math in big-city schools, Paige declared that the reforms have produced "islands of excellence, but that isn't good enough."

The next version of the global test will be administered in 2003.