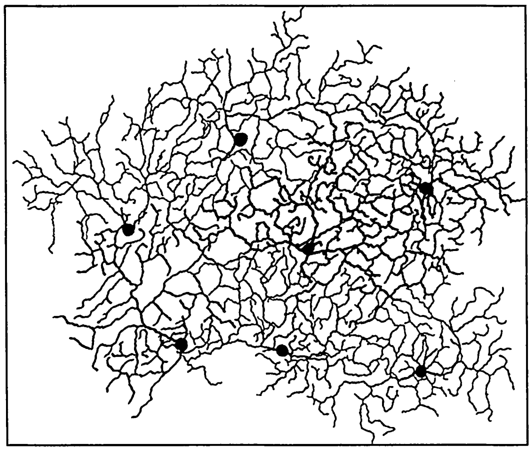


Calculators? Retinal ganglion cells like these may compute when to fire by summing up the excitatory and inhibitory signals they receive.

of additional studies.

The first sign that retinal ganglion cells do computations came in 1965 when Horace Barlow of the University of Cambridge in the U.K. and William Levick, a co-author on the current paper, showed that some of the cells respond only to objects moving in a certain direction. The ganglion cells are third or fourth in a chain of neurons triggered when light strikes the retina. Barlow and Levick proposed that neurons somewhere in this path calculate movement direction from the timed interplay of excitatory and inhibitory neural impulses.

In their scenario, when an object moved in the neuron's preferred direction, excitatory impulses would reach the target neuron first, triggering positively charged sodium ions to flow into the cell—an excitatory current. But when the object moved in the opposite direction, inhibitory and excitatory signals would arrive together. The inhibitory signal would cause chloride ions to enter the cell, their negative charge effectively canceling the excitatory effect. A decade later, Nigel Daw's team at Washington University in St. Louis confirmed that inhibitory impulses are required for directional selectivity, but a key question remained. Do the inhibitory and excitatory impulses converge on the ganglion cells or on earlier cells in the pathway?

To answer that question, Taylor used a method called patch clamping, which enables researchers to detect electrical changes in a single cell—in this case, ganglion cells in cultured rabbit retinas. Taylor and postdoc Shigang He found, as expected, that movement in a cell's preferred direction caused a greater excitatory current to enter the cells' dendrites, the structures that receive incoming signals. But that didn't pinpoint the site of computation; cells earlier in the pathway might be analyzing motion and delivering a larger excitatory signal to the ganglion cells in response to movement in the preferred direction.

To find out, the researchers shifted the voltage across the dendrite membrane of individual ganglion cells in a way that would favor inhibitory currents over excitatory ones. They found increased inhibitory currents in response to movement in the nonpreferred (null) direction, suggesting that inhibitory inputs play a role in the ganglion cell's response. Next they flooded the interior of the dendrites with chloride to block the inhibitory inward flow of chloride ions; that change abolished directional selectivity. These results provide "strong evidence" that the computation is going on in the ganglion cell dendrites, says Borst.

What's more, indirect evidence suggests that ganglion cells are capable of something called shunting inhibition, a phenomenon in which chloride channels are opened by inhibitory signals, but there is no net flow of chloride through them unless an excitatory signal comes along at the same time and drops the voltage across the membrane. This voltage change drives chloride through the open channels into the dendrite, where their negative charge electrically nullifies that incoming excitatory signal. In neighboring dendrites the calculation may be different; excitations arriving without inhibition could add up to help make the neuron fire. This model provides a much more complex vision of neuronal computation than does the view in which a neuron simply sums up all the excitatory and inhibitory signals it receives.

Shunting inhibition has been found in brain neurons, but the computations they perform are not known. Assuming that retinal ganglion cells do in fact calculate direction, researchers can investigate whether shunting inhibition occurs in these cells and, if so, how it contributes to computation, something many have been eager to do in neurons of well understood function, says California Institute of Technology neuroscientist Christof Koch.

But Lyle Borg-Graham, a neuroscientist at the French research agency CNRS in Gif-sur-Yvette, is not convinced that retinal ganglion cells have computational powers. He reported last July at a meeting in Brugge, Belgium, that his team has evidence that the critical direction-selective computation in turtle retinas occurs earlier in the signaling pathway. "I doubt that the different interpretations may be ascribed to using the turtle as opposed to the rabbit," says Borg-Graham.

The reason for the discrepancy is not clear. But when it is resolved, both camps agree, this particular window into the brain may provide quite an exciting view.

—MARCIA BARINAGA

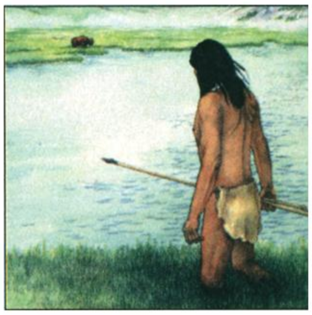
ANTHROPOLOGY

Bones Decision Rattles Researchers

The Interior Department has decided to turn over the 9300-year-old remains of Kennewick Man to the five Indian tribes that have laid claim to them. But scientists suing to study the remains, found 4 years ago on the banks of Washington's Columbia River, say they will continue to pursue their case.

Last March, federal Judge John Jelderks gave the government until September to try to get some DNA out of the bones before deciding whether to allow academic anthropologists to study them (*Science*, 17 March, p. 1901). Three labs have since failed to obtain any DNA and, thus, suggest a link to a particular people or culture. This week, however, Interior Secretary Bruce Babbitt said the bones have been studied enough and that they should go to the Indians under the controversial Native American Graves Protection and Repatriation Act (NAGPRA).

NAGPRA applies to remains that are "native American" and "culturally affiliated" with existing groups. But many scientists say the Kennewick skull bears a greater resemblance to early Pacific rim inhabitants than to modern native Americans. And there is no cultural evidence connecting him to existing tribes: The only artifact accompanying the bones was a projectile point in Kennewick's pelvis. Nonetheless, in a letter to the Army Corps of Engineers, Babbitt said reports by four scientists have persuaded him that "the geographic and oral tradition evidence establishes a reasonable link between these remains and the present-day Indian tribe claimants." He referred to the "continuity of human occupation" in the area for more than 10,000 years and the fact that oral traditions support a very long residency for the tribes.



Looking for a home. A court may decide the final destination of Kennewick Man.

Scientists who want to study the bones aren't happy with Babbitt's decision. It is "absolutely absurd" and "cannot be supported either scientifically or from a legal standpoint," says Alan Schneider, a Portland, Oregon, lawyer for the scientists. Anthropologist Richard Jantz of the University of Tennessee, Knoxville, one of the plaintiffs, says "I can't imagine how the government can defend its decision in court." No trial date has been set.

—CONSTANCE HOLDEN