ferent NMDA receptor subunit (NR2A) by EphB2 signaling (*2*). These observations suggest that ephrin ligands activate EphB2 receptors on the postsynaptic membrane, which leads to recruitment of a Src family kinase to the EphB2 receptor. The Src family kinase, in turn, phosphorylates one or more NR2 subunits, and this posttranslational modification leads to increased calcium permeability of the NMDA receptor (see the figure). In this way, ephrinB signaling could exert a marked influence on synaptic plasticity at glutamatergic synapses.

The Grunwald *et al.* (*2*) and Henderson *et al.* (*3*) papers provide in vivo evidence that the EphB2 receptors are involved in synaptic plasticity. Both groups report that synaptic plasticity is compromised in mice that lack the *ephB2* gene, although the studies differ in some important respects. Henderson *et al.* (*3*) report that synaptic plasticity in the hippocampus is reduced at both CA1 and dentate gyrus synapses in *ephB2*-deficient mice. They also found that NMDA receptor–mediated synaptic currents in hippocampal granule cells are reduced in the mutant mice. Grunwald *et al.* (*2*) also report a reduction in synaptic plasticity at CA1 synapses, but they did not observe differences in NMDA receptor–mediated currents in CA1 neurons. Thus, it is not yet clear whether altered plasticity in *ephB2*-deficient mice can be entirely explained by changes in NMDA receptor activity. Although this is an important issue that needs to be resolved, the studies agree on the principal conclusion that EphB2 receptors contribute to hippocampal synaptic plasticity.

Together the studies from the Greenberg, Klein, and Pawson laboratories (*1–3*) strongly suggest that EphB2 receptors can modulate NMDA receptor–mediated synaptic plasticity, but several mechanistic details are not yet resolved. Perhaps the most surprising finding is that of the Klein and Pawson groups (*2*, *3*), who report that the in vivo deficits in *ephB2*-deficient mice can be rescued by overexpressing an EphB2 receptor that lacks the cytoplasmic domain. At first glance, this appears to be at odds with the observation from the Greenberg group that EphB receptor–induced potentiation of NMDA receptor activity requires the cytoplasmic domain of the EphB receptor. But the Greenberg lab had previously shown that EphB2 receptors induce NMDA receptor clustering in neurons, and that this effect does not require the EphB receptor's cytoplasmic domain (*6*). Therefore, one possible explanation is that the in vivo deficits in synaptic plasticity are principally due to lack of proper clustering of NMDA receptors at the synapse. This further underscores the importance of determining whether the localization and function of NMDA receptors are affected in *ephB2*-deficient mice, and whether that can explain the observed effects on synaptic plasticity.

One of the most interesting implications of the Greenberg study (*1*) is that EphB2 receptor signaling can acutely influence NMDA receptor activity. It will be important to further examine this possibility in vivo, both in the context of developmental maturation and adult synaptic plasticity. It should be determined whether NMDA receptor–mediated calcium influx is reduced in *ephB2*-deficient mice, and whether the effects of EphB2 signaling on NMDA receptor clustering and calcium permeability can be mechanistically separated by genetic manipulation. It would also be interesting to know whether the effects of EphB signaling on the NMDA receptor are partly regulated by insertion of NMDA receptors into the postsynaptic membrane, which is one way in which glutamate receptor activity is modulated. Addressing these questions should provide important insights into the link between EphB receptor signaling and NMDA receptor activity, simultaneously enhancing our understanding of the molecular basis of synaptic plasticity.

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PERSPECTIVES: CLIMATE CHANGE

On Thickening Ice?

Richard B. Alley

The big ice sheets in Greenland and Antarctica are key elements of the global climate system. By storing large volumes of water as ice or ice-contact lakes and sometimes releasing that water abruptly, they can affect sea level, global ocean circulation, and hence Earth's climate, as highlighted on page 476 of this issue by Joughin and Tulaczyk (*1*).

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Modern attention is especially focused on the West Antarctic Ice Sheet (*2*). Its bed is well below sea level and deepens toward the center. In some models and in reconstructions of the behavior of some past ice sheets, these characteristics are linked to instability. The West Antarctic Ice Sheet has changed greatly since it first formed a few million years ago (*3*) and has been far from static since humans began observing it a few decades ago (*1*). Yet in the modern warm period (interglacial), it has long outlasted the melting of most ice-age ice, and circumstantial evidence indicates that the ice sheet persisted through the previous interglacial (*4*) and probably the two interglacials before that (*3*).

Predicting the future of the West Antarctic Ice Sheet bears many challenges. Even just measuring the mass balance—whether the ice sheet is growing or shrinking—has proved difficult. One approach is to compare the snow input with the flow output. This requires enough ice-core or other data to determine accumulation rates and enough velocity measurements to capture the ice outflow. Much West Antarctic ice discharges through ice streams with slippery beds. This simplifies the problem as surface and bed velocities are similar, allowing measurements of surface velocities and ice thicknesses to constrain ice outflow.

Early, often heroic efforts to measure mass balance produced important baseline data but left considerable uncertainties because sampling was too sparse to capture the spatial variability. Improvements in ice-core analyses, airborne geophysical surveying, and satellite remote sensing are rapidly reducing these uncertainties and form the basis of the new work by Joughin and Tulaczyk (*1*). Focusing on the West Antarctic drainage into the Ross Sea, the authors show that on average the ice sheet is thickening slowly.

This new result differs from the best older estimates, which indicated a net thinning for this region (*5*). Improved data from interferometric synthetic-aperture radar and other techniques contributed to the difference. However, the discharge from this region also has decreased substantially over the last decades as Whillans Ice Stream (formerly called Ice Stream B) slowed near the Ross Ice Shelf (*6*). Considering the century-old near stoppage of adjacent Ice Stream C (see the figure) (*5*), it is tempting to identify a trend. Perhaps after 10,000 years of retreat from the ice-age

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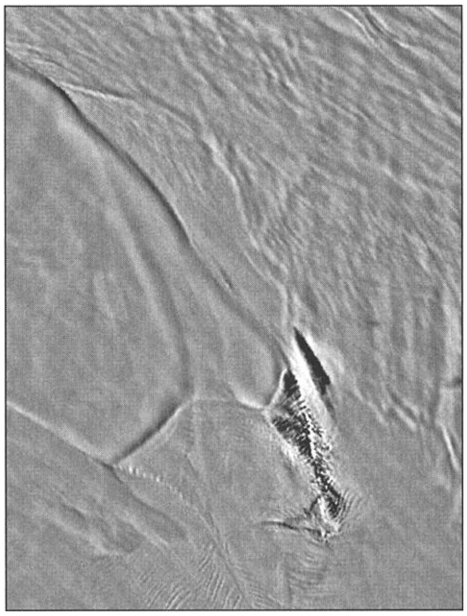

A complex picture. Composite MODIS satellite image of Whillans Ice Stream (upper right, flowing to lower right) and the adjacent Ridge BC or Ridge Whillans/C (left), feeding the Ross Ice Shelf (lower right). The slower flowing ridge appears smooth compared with the faster flowing ice stream. The former shear margin of Ice Stream C, which slowed greatly just over a century ago, is visible toward the lower left crossing the ridge onto the ice shelf and joins a former Whillans-Ice-Stream shear margin that now crosses a corner of the ridge. The slowdown of C and narrowing of Whillans Ice Stream are consistent with the reduced discharge and net thickening of the Siple Coast region reported in (*1*). However, the dark regions (crevasses and rifts) in the lower center, near where the ice stream, ridge, and ice shelf meet, are probably linked to a widening of the ice stream back into the ridge (*6*). In addition, ice rise "a" (upper right corner) is apparently a piece of slow-moving ridge ice incorporated into and moving with the high-speed ice stream (*5*). The widening of Whillans Ice Stream and incorporation of ice rise "a" show that changes in the region can involve speed up and thinning as well as slowdown and thickening.

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maximum (*7*), researchers turned on their instruments just in time to catch the stabilization or readvance of the ice sheet.

Earlier work by Tulaczyk *et al.* (*8*) may even explain why. Basal melting occurs—and allows faster motion—where the heat from Earth's interior and from flow friction exceeds the heat conducted into the ice. The thinning that may have accompanied postglacial retreat of the ice sheet would have moved cold surface ice closer to the bed, increasing basal heat loss and thus favoring basal freezing and ice-stream slowdown.

Lest coastal property owners become too optimistic, however, it is important to remember how short the instrumental record is and how poorly characterized the natural variability. Sedimentary records indicate that ice streams have paused or even readvanced during the retreat since the last ice age (*9*). And observations from boreholes through ice streams suggest the presence of excess basal water supplied by melting beneath thicker ice inland (*10*). Latent heat from freezing of this water can warm the cold ice without freezing the ice streams to their beds (*11*).

Joughin and Tulaczyk (*1*) also highlight the great complexity of the system. They studied ice streams that feed the floating Ross Ice Shelf and that are slightly impeded by friction produced where the ice shelf runs aground (*12*). Reduced ice-stream flow into the ice shelf may allow it to thin and float free of the impeding grounding points, perhaps rejuvenating the ice streams and thus the ice shelf. Failure of this complex feedback path may lead to ice-shelf shrinkage or loss, with implications for formation of oceanic deep waters and thus for large-scale climate.

Access logistics and contrasting ice-stream styles have focused research on the Ross (*1*) and Filchner/Ronne (*13*) drainages. Yet the logistically difficult Pine Island Bay drainage is probably the most likely of the three major basins to experience the onset of dramatic ice-sheet changes (*14*). Here, thick, fast-moving ice discharges into relatively warm ocean waters without the protection of a large ice shelf. Speed up of ice flow and thinning are indeed occurring (*15*) but it remains unknown whether these changes will persist in the long term. Fortunately, the research tools developed by Joughin and Tulaczyk (*1*) and other researchers should allow rapid progress.

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PERSPECTIVES: SUPERCONDUCTIVITY

Tuning Order in Cuprate Superconductors

Subir Sachdev and Shou-Cheng Zhang

In 1986, superconductivity—the ability to transport electrical current without substantial resistance—was discovered in cuprate compounds. These materials have fascinated physicists ever since, in part because of the high critical temperatures (T_c's) below which superconductivity is present and the consequent promise of technological applications. However, cuprate superconductivity also raises fundamental questions about the collective quantum properties of electrons that are confined to a lattice and interact with each other (the "correlated electrons" problem). On page 466 of this issue, Hoffman *et al.* (*1*) report an innovative scanning tunneling microscopy (STM) study that should help answer some of these questions.

All discussions of cuprates begin with the compound La_2CuO_4. Its valence electrons reside on some of the 3d orbitals of the Cu ions, which are arranged in layers. In each layer, the Cu ions are located on the vertices of a square lattice, and the ability of electrons to hop between successive layers is strongly suppressed by the negligible interlayer overlap of the 3d orbitals. La_2CuO_4 is an insulator; its inability to transmit electrical current within a layer is a result of the Coulomb repulsion

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