

Figure 1 A new way of regulating synaptic activity. Liu and Cull-Candy¹ have found that the composition of AMPA receptors (a subtype of receptors for the neurotransmitter glutamate) in cerebellar stellate interneurons can change in response to neuronal activity. These receptors regulate their own function, perhaps as follows. **a**, Under control conditions, synapses are characterized by a high proportion of calcium-permeable AMPA receptors that lack the subunit GluR2. **b**, Release of glutamate from the presynaptic neuron and its binding to AMPA receptors of the postsynaptic neuron leads to calcium influx through the AMPA receptors. The resulting increase in intracellular calcium concentration induces an alteration in the subunit composition of the AMPA receptors themselves (**c**), resulting in the expression of GluR2-containing receptors with low calcium permeability.

receptor function usually requires an influx of calcium ions into the neurons. How is this increase in intracellular calcium concentration achieved? Many neurons express AMPA receptors that exhibit very low permeability to calcium, because the receptors contain a specific subunit, GluR2 (ref. 7). Calcium influx into these neurons can be achieved by activation of another type of glutamate receptor, the NMDA (*N*-methyl-D-aspartate) receptor, or through voltage-gated calcium channels in the plasma membrane. In contrast, AMPA receptors that lack GluR2 exhibit relatively high calcium permeability. Cells expressing a high proportion of these receptors can use this route for calcium entry.

Liu and Cull-Candy¹ now describe a mechanism of synaptic plasticity based, unusually, on changes in the composition and function of AMPA receptors. They provide evidence that activity regulates the molecular composition of AMPA receptors in postsynaptic stellate interneurons of the cerebellum. The authors use a variety of pharmacological tools to show that these interneurons do not use NMDA receptors. Instead, the synapses are characterized by a high proportion of calcium-permeable, GluR2-lacking AMPA receptors. By contrast, at the cell bodies of the interneurons (that is, at extrasynaptic regions), Liu and Cull-Candy find mainly GluR2-containing AMPA receptors, with low calcium permeability.

What are the mechanisms responsible for the targeting of the different AMPA-receptor subunits to different subcompartments of these neurons? Liu and Cull-Candy tackled this problem by applying high-frequency stimulation to the presynaptic axons. Surprisingly, within just 15 to 30 minutes, the properties of the AMPA-receptor-mediated currents in the postsynaptic interneurons changed strikingly, indicating

the inclusion of GluR2-containing receptors. The results convincingly show the rapid, activity-dependent change in function at these synapses.

Liu and Cull-Candy next went on to show that an increase in the level of intracellular calcium was necessary for the alteration in receptor composition. They then analysed the different routes of calcium entry into the cell. They discovered that calcium influx through the synaptic AMPA receptors themselves was sufficient to produce a rise in intracellular calcium that resulted in alteration of the function of these receptors. By contrast, the function of extrasynaptic receptors on the cell bodies was determined mostly by calcium influx through *N*-type calcium channels during action potentials. So, at some synapses in the brain, receptor-mediated calcium influx can regulate the subunit composition — and thereby the calcium permeability and the electrical properties — of the very same receptors. This provides an activity-dependent feedback mechanism controlling the properties of synaptic transmission.

What might be the physiological function of this self-regulating mechanism? At present, this question is difficult to answer. Perhaps these synapses function in two ways

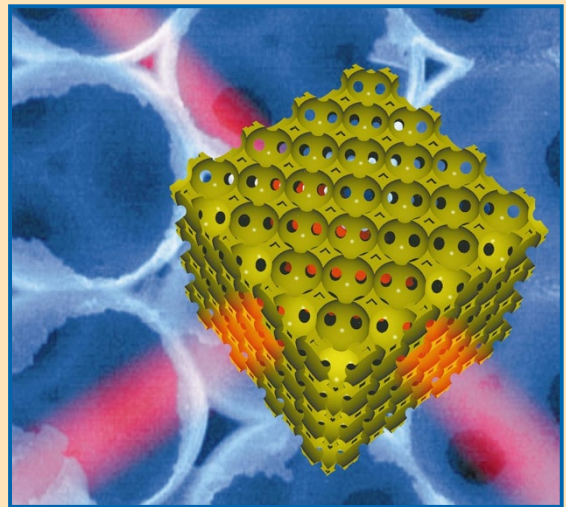
Photonics

Opal appeal

Photons are the best messengers for really quick information transmission. But creating circuitry that can process light with the versatility of electronic silicon chips is a big technological challenge. The most promising approach relies on fabricated structures known as 'photonic crystals'. These materials have carefully tailored properties that make them opaque to selected wavelengths — providing a means to control the routing and transmission of optical signals.

Elsewhere in this issue, Alvaro Blanco and colleagues (*Nature* **405**, 437–440; 2000) describe a simple and cheap method for the large-scale manufacture of three-dimensional silicon photonic crystals. The picture here shows a computer representation of the structures, superimposed on a real image from a scanning electron microscope. Because the crystals are made of silicon, they should be easy to integrate with conventional electronic circuitry.

How is this complex



structure produced? The first step is to construct a three-dimensional template that will ultimately be discarded. It consists of a form of artificial opal: uniformly sized silica spheres, up to a micrometre in diameter, grown from seed particles. Application of heat causes small bridges to develop between the spheres, resulting in a connected structure. Next, gases containing silicon are allowed to infiltrate the template. The voids in between the spheres are gradually filled up as the silicon crystallizes. The final step is to dissolve

away the silica sphere-and-bridge template using an acid etching process.

Theoretical calculations predict that the resulting structure should block wavelengths around 1.5 μm — perfect for manipulating the infrared signals used in fibre-optic communications. The measured reflectance and transmission spectra of the photonic crystals confirmed this behaviour. Equally importantly, the crystals are unlikely to absorb valuable signal power, as bulk silicon only soaks up higher energies. **Karen Southwell**

A. BLANCO ET AL.