a century of debate over the mechanism of direction selectivity in ganglion cells.

Although a DSGC can receive synapses from SAC dendrites with any preferred direction, the number of synapses tends to be much larger for certain directions. Therefore, methods that merely establish whether a SAC dendrite is connected to a DSGC cannot reveal the specificity of connectivity. It is essential to quantify the strength of interaction by counting the number of synapses involved, as Briggman and co-workers have done.

In the neocortex, most neurons are excitatory and almost all of these are of the pyramidal type. There are also many types of inhibitory neurons and many rules of neocortical connectivity based on cell type[8]. But pyramidal neurons, even in the same cortical location and layer, can differ in their functional properties. For example, a pyramidal neuron in the primary visual cortex is preferentially activated by visual stimuli of one orientation, and the preferred orientations of pyramidal neurons are diverse.

Bock *et al.* (page 177) find that inhibitory neurons receive synapses from pyramidal neurons with a wide range of preferred orientations. This lack of specificity may explain observations[9–11] that inhibitory neurons are untuned, or only weakly tuned, to stimulus orientation: if an inhibitory neuron indiscriminately sums over synaptic inputs from pyramidal neurons of all preferred orientations, then its output would lack orientation selectivity.

The authors[2], however, acknowledge their study's limitations. Even if an inhibitory neuron receives synapses from pyramidal neurons with a wide range of preferred orientations, its summed synaptic input could still be biased towards a particular orientation by more or stronger synapses (see Fig. 5d of ref. 2, for example). Other researchers[12] have reported that one type of inhibitory neuron is sharply tuned to a particular orientation. So although Bock *et al.* have not said the last word on the subject, they have made a step in the right direction.

Neural-network theorists are eager to see the controversies resolved, as they have long speculated that inhibitory neurons receive indiscriminate connections from pyramidal neurons and send back inhibition to prevent runaway excitation[13] or to sharpen response selectivity[14,15]. If this idea is correct, inhibitory neurons have a supporting role in visual computations: they are not primarily responsible for generating selectivity to visual features, but rather they help pyramidal neurons to achieve it.

The two teams[2,3] imaged relatively small volumes of the brain (less than 1% of a cubic millimetre). Furthermore, the volumes were relatively thin — about 50–60 μm — along one dimension. This is not a problem for the retina, which is a thin sheet. (The inner plexiform layer of the retina, which contains the SAC–DSGC connections, is even thinner.) But many cortical axons left the confines of the volume that Bock *et al.* imaged. This limited the size of their sample of connections, and biased it towards nearby neurons.

Why not study larger volumes? Although the present studies benefited from recent inventions, they still required heroic efforts to acquire and analyse terabytes of image data. To tackle larger volumes, the speed of both image acquisition and analysis must be increased. Analysis should be accelerated by augmenting human intelligence — as used in these papers — with artificial intelligence, and progress is being made along these lines[16].

Another limitation of the studies[2,3] is in the fraction of connections mapped within the volume. Mapping a larger fraction would allow the application of sophisticated computational methods for analysing connectivity to understand function[17].

Briggman *et al.* show that DSGCs inherit their direction selectivity from SAC dendrites, whereas Bock *et al.* find that inhibitory neurons in the visual cortex squander their inheritance, discarding the orientation selectivity of their inputs. To understand vision, it will be essential to investigate whether and how connectivity enables a neuron to compute a property that is not already present in any single one of its inputs. Iteration of such connectivity could yield neurons that are selective to more and more complex features, as in many neural-network models of the visual system[18]. It is hoped that functional connectomics will finally succeed in revealing how this happens.

These papers[2,3] have introduced a general approach to relating the structure of neural networks to their function: search for rules of connectivity that depend on functional properties of neurons. Finding such rules will be more arduous than finding connections between brain regions, or rules of connection between neuronal cell types. But it is crucial for testing the claim that "Nothing defines the function of a neuron more than its connections with other neurons"[19]. This battle cry will be heard more often as the nascent field of connectomics matures. ■

H. Sebastian Seung *is in the Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA.*
e-mail: seung@mit.edu

1. Masland, R. H. *Curr. Biol.* **14,** R497 (2004).
2. Bock, D. D. *et al. Nature* **271,** 177–182 (2011).
3. Briggman, K. L., Helmstaedter, M. & Denk, W. *Nature* **271,** 183–188 (2011).
4. White, J. G., Southgate, E., Thomson, J. N. & Brenner, S. *Phil. Trans. R. Soc. Lond. B* **314,** 1–340 (1986).
5. Sporns, O., Tononi, G. & Kotter, R. *PLoS Comput. Biol.* **1,** e42 (2005).
6. Helmstaedter, M., Briggman, K. L. & Denk, W. *Curr. Opin. Neurobiol.* **18,** 633–641 (2008).
7. Euler, T., Detwiler, P. B. & Denk, W. *Nature* **418,** 845–852 (2002).
8. Douglas, R. J. & Martin, K. A. C. *Annu. Rev.*

50 Years Ago

The Mango. By Dr. Lal Behari Singh — It is pleasing, as it is unexpected, to find a new series of books on world crops starting off not with such solid fare as wheat or potatoes or cabbage but with something as exotic and appetizing as the mango. This "choicest fruit of Hindoosthan" has spread far beyond the bounds of India and has become one of the most cherished fruits of tropical lands. It is still found in greatest variety and excellence in India, and this book comes, fitly enough, from the pen of a distinguished Indian horticulturist. This book may be counted on to commend itself as the most complete study of the mango so far published … While the botanical chapters refer mainly to the common mango, *M. indica*, the author directs attention to fifteen other species of *Mangifera* with edible fruits. Evidently there is great wealth of related material here, of possible value for future breeding … The section on utilization is necessarily brief, since the best way to use a mango is still to eat it as promptly and as dexterously as possible, but some mango recipes are also given … This book deserves to be welcomed and to be gratefully added to the small, but growing, collection of hand-books on the tropical crops.
From *Nature* 11 March 1961

100 Years Ago

Can any correspondent of *Nature* recall a case of a cat playing with a shadow? I know of a cat — a blue Persian — which appears to wait until the morning sun throws the shadow of a cage-bird on the wall of a room, and then seems to play at catching the shadow of the bird as it moves about.
From *Nature* 9 March 1911