Learn more when your neighbors do

Synaptic neighbors help each other learn, according to Christopher Harvey and Karel Svoboda (HHMI, Chevy Chase, MD).

Learning and memory, which require a strengthening of synaptic connections known as long-term potentiation (LTP), have traditionally been thought to be synapse specific, with one synapse unable to influence LTP induction in even its closest neighbors. But computational modeling has suggested that this kind of influence could allow individual neurons to store more information.

To test whether brains exploit this theoretical advantage, the authors stimulated individual dendritic spines with the neurotransmitter glutamate. Next, a weaker stimulus was applied to nearby spines. This weak stimulus is too low to trigger LTP on its own, but it caused robust potentiation when following the stronger stimulus.

“It made it easier for [synapses] to learn in the future if their neighbors had learned something in the past,” Harvey says. But too far in the past, or too distant a neighbor, didn’t help: the subthreshold stimulus had to occur within 10 min and 10 μm of the first. The two synapses also had to be on the same branch, suggesting that the bolstering signal probably travels intracellularly from spine to spine. So far, the group has no leads on this roaming internal signal.

The authors suggest that such “clustered plasticity” may link memories that are laid down in close succession on the same dendritic branch. Whether this neighbor effect increases storage capacity remains to be seen. JCB

Reference: Harvey, C., and K. Svoboda. 2007. Nature. 450:1195–1202.

Organelles in parallel

Endocytic organelles in three eukaryotic kingdoms evolved in parallel, according to Joel Dacks, Mark Field (University of Cambridge, UK), and Pak Poon (Dalhousie University, Halifax, Canada).

Unlike mitochondria and chloroplasts, the membrane trafficking system did not arise through endosymbiosis; it evolved from within. When fungi, plants, and animals split off from their last common ancestor, some parts of the system were “caught midstream in the process of becoming discrete organelles,” says Dacks.

To track the development of the system, the authors performed phylogenetic analyses of three components: Rab5 and β-adaptors, which help sort cargo into vesicles, and the endocytic syntaxins, which assist vesicle fusion. The team found that in the common ancestor, each was represented by a single molecule that performed multiple functions. After divergence, the components evolved in parallel through gene duplication and specialization. For instance, syntaxin E homologues in each kingdom now include one that drives fusion at the early endosome and another that helps fuse late endosomes to the lysosome. These two sets of syntaxins arose after the eukaryotic split and independently adopted similar functions within each group.

“The distinction among the endosomes was less clear at the start and was firmed up afterward,” says Field. The need for increased cargo specificity and sorting efficiency in each group seems to have driven the parallel evolution. JCB

Reference: Dacks, J., et al. 2008. Proc. Natl. Acad. Sci. USA. doi:10.1073/pnas.0707318105.

H⁺, the tiniest transmitter

Protons make muscles move in the worm gut, making the H⁺ ion the newest and smallest chemical transmitter known, according to Asim Beg, Erik Jorgensen (University of Utah, Salt Lake City, UT), and colleagues. The protons are released by intestinal cells and stimulate defecation.

The group discovered the phenomenon while looking for neurons that control defecation. After killing the neurons innervating the posterior body muscles, the authors found that contractions nevertheless continued. To find out how, they screened for mutants in muscle contraction and identified two genes. One was pbo-5, which encodes a receptor on the muscle surface. The other was pbo-4, whose protein product sends protons out of the intestinal epithelium. Classical neurotransmitters did not activate the PBO-5 receptor or muscle contraction, but the release of caged protons did, even in pbo-4 mutants, which are unable to release their own gut protons. By contrast, pbo-5 mutants did not respond to proton release.

“These protons possess all the attributes of a classical transmitter,” says Jorgensen, including having a specific receptor. The brain might also use protons to control neuronal signaling. According to him, the gut signaling role for protons “demonstrates the creativity of evolution. Cutting out the middle man—the nervous system—allows direct communication between the epithelium and the muscle.” JCB

Reference: Beg, A., et al. 2008. Cell. 132:149–160.

The Na⁺/H⁺ exchanger pbo-4 (green) is expressed on the basolateral surface of intestinal epithelial cells.