ACS Chemical Neuroscience

Editorial

pubs.acs.org/chemneuro

Adventures in Neurobioengineering

Many biologists believe that innovations in laboratory technology should take place only within the framework of hypothesis-driven studies. This view largely ignores the history of transformative discoveries in the life sciences, which in many cases have been enabled by tools imported from other disciplines or invented for other purposes. The view that technological advances must be driven by "normal science" is also at odds with some of the most exciting, yet rather applied movements in modern biology, such as the investigation of RNA interference phenomena and the growth of stem cell research. Technological innovations have been a particularly potent guiding force in neurobiology, a field midwifed by the advances in microscope design and mathematical optics that took place in the late 19th century. Saltatory progress ranging from the establishment of the neuron doctrine[1] to human functional brain mapping[2,3] has been spawned directly by the introduction of disruptive modalities for measuring and manipulating components of the nervous system.

Although physics and chemistry have probably most influenced the experimental paradigms of neuroscience (in addition to optics, witness detectors for bioelectricity and biomagnetism, X-ray crystallography, electron microscopy, magnetic resonance, chemical probes and histochemical stains, and pharmacology), biology itself has bred powerful tools. The molecular biology revolution of the 1970s saw the discovery of prokaryotic mechanisms for DNA and protein processing and gave scientists dominion over a host of molecules that are now workhorses of biotechnology in general. More recent breakthroughs with special significance to neurobiology have included the discovery of green fluorescent protein (GFP)[4] and construction of GFP-based reporters, as well as the introduction of genetically targeted optical stimulation techniques.[5−7] The subversion of biological entities to support research in the nervous system has become an important part of the expanding field of "neurobioengineering." This field encompasses efforts to use natural or artificially constructed biomolecules to interrogate or alter neuronal function, attempts to engineer whole neural genomes, cells, and cell populations, and the design and incorporation of devices that facilitate these aims in both scientific and medical contexts.

In this special issue of *ACS Chemical Neuroscience*, we highlight six topics currently at the forefront of neurobioengineering. Xue Han discusses recent progress in optogenetic stimulation and silencing, perhaps the most prominent neurobioengineering success story to date. Shapiro et al. review the complementary strategy of pharmacogenetic manipulation of neuronal activity, which operates on a longer time scale and more global spatial reach than optogenetics. Mutoh et al. discuss advances in one of the most active areas of optical biosensor development, the development of fluorescent protein-based voltage sensors. Hsieh and Jasanoff examine biological engineering based approaches for magnetic resonance imaging of molecular targets in the nervous system. Hsu and Zhang review new methods for manipulating genomic DNA, with applications to the study and treatment of neurological diseases. And Fabbro et al. describe the engineering of neuronal functionality using nanoscale reagents. The small collection of snapshots this issue provides cannot do justice to the diversity of creative work in neurobioengineering, but it offers insight into some of the biology-based technologies that will surely shape the practice of neuroscience in coming years.

Alan Jasanoff, Associate Editor

AUTHOR INFORMATION

Funding

The author acknowledges support from the NIH (DP2-OD002114, R01-DA028299, R01-NS076462) and DARPA (W911NF-10-0059).

Notes

Views expressed in this editorial are those of the author and not necessarily the views of the ACS.

REFERENCES

(1) Cajal, S. R. (1888) Estructura de los centros nerviosos de las aves. *Rev. Trim. Histol. Norm. Patol. 1*, 1−10.
(2) Phelps, M. E., Kuhl, D. E., and Mazziota, J. C. (1981) Metabolic mapping of the brain's response to visual stimulation: studies in humans. *Science 211*, 1445−1448.
(3) Belliveau, J. W., Kennedy, D. N., Jr., McKinstry, R. C., Buchbinder, B. R., Weisskoff, R. M., Cohen, M. S., Vevea, J. M., Brady, T. J., and Rosen, B. R. (1991) Functional mapping of the human visual cortex by magnetic resonance imaging. *Science 254*, 716−719.
(4) Shimomura, O., Johnson, F. H., and Saiga, Y. (1962) Extraction, purification and properties of aequorin, a bioluminescent protein from the luminous hydromedusan, Aequorea. *J. Cell. Comp. Physiol. 59*, 223−239.
(5) Zemelman, B. V., Lee, G. A., Ng, M., and Miesenbock, G. (2002) Selective photostimulation of genetically chARGed neurons. *Neuron 33*, 15−22.
(6) Banghart, M., Borges, K., Isacoff, E., Trauner, D., and Kramer, R. H. (2004) Light-activated ion channels for remote control of neuronal firing. *Nat. Neurosci. 7*, 1381−1386.
(7) Boyden, E. S., Zhang, F., Bamberg, E., Nagel, G., and Deisseroth, K. (2005) Millisecond-timescale, genetically targeted optical control of neural activity. *Nat. Neurosci. 8*, 1263−1268.

Special Issue: Biological Engineering in Neuroscience

Published: August 15, 2012

