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By Alla Katsnelson

Ed Boyden: The brain engineer

At the end of his junior year at the Massachusetts Institute of Technology in 1998, Ed Boyden was hanging out with friends in the basement of the famed Media Lab, trying to figure out what to do for the summer. "We saw this competition online and thought, hey, that's cool," recalls Boyden of the first International Underwater Vehicle Competition. "None of us knew anything about submarines at all." Eight weeks later, the initial crew had expanded to a team of about 30 and took home first prize with the autonomously navigating submarine they built.



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More than 10 years later, Boyden is back at MIT's Media Lab, combining cellular and systems neuroscience with engineering, studying neural circuits and designing new technologies to control them in order to treat neurological disorders. It's a far cry from submarines, but the approach, he says, is the same: understand the theory and build something useful out of it.

Boyden majored in electrical engineering and physics as an undergraduate, and continued his graduate work at MIT studying quantum computing, but soon got frustrated with the slow movement and dearth of experimentation in the field. "I've always thought that if we could apply engineering principles to the understanding of the brain, that would be very powerful."

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So he moved on to Stanford University, doing his doctoral research on learning and memory in the cerebellum under the joint supervision of Jennifer Raymond and Richard Tsien. Relying on behavioral and molecular techniques, Boyden showed that several different cellular mechanisms drive different types of

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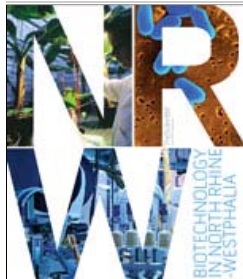
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his day [is] action-packed." Both his advisors recall with a laugh Boyden's habit of taking notes on all his conversations and ideas. "He does this, so far as I can tell, every waking moment," says Raymond.

Toward the end of his PhD, he and Karl Deisseroth, a young professor at Stanford, started tinkering with a recently-discovered light-activated protein called channelrhodopsin-2 (ChR2). By expressing the protein in neurons, they could activate those neurons with the flick of a light switch. ² The technique is now used in more than 250 labs.



The head of the synthetic neurobiology group and joint professor of bioengineering at MIT since 2006, Boyden and his team use ChR2 in mouse models to characterize the circuitry involved in epilepsy, Parkinson's disease and most recently, post traumatic stress disorder. Recently, Boyden and Bob Desimone, director of MIT's McGovern Institute for Brain Research, used lentiviruses to target a specific subtype of excitatory neurons in monkeys, demonstrating that the technique works safely in vivo. ³ The group also applies its considerable engineering prowess to building brain-related devices. One effort, which bubbled up from an undergraduate thesis, involves designing a portable and inexpensive technology for transcranial magnetic stimulation, which is being investigated as a treatment for several brain disorders and was recently FDA-approved for the treatment of depression.

So-called side projects are still major idea generators for his group. Boyden established a lab "venture capital fund"—around \$50,000—dedicated to testing seemingly improbable ideas. The one rule: two weeks must yield enough data to decide if the project is worth pursuing. One successful project attempted to disrupt neural oscillations to treat epilepsy. A couple weeks of initial data garnered the group a multi-institutional grant to study neural control. "It's turned into a major endeavor," says Boyden.

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Title: Assistant professor at the MIT Media Lab
Age: 29
Representative publications:

1. E.S. Boyden et al., "Selective engagement of plasticity mechanisms for motor memory storage," *Neuron*, 51:823–34, 2006. (Cited in 12 papers)
2. E.S. Boyden et al., "Millisecond-timescale, genetically-targeted optical control of neural activity," *Nature Neurosci*, 8:1263–8, 2005. (Cited in 109 papers)
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