Mechanically-Controlled Rewiring of Neuronal Circuits

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We have used atomic force microscopy to present spatially and temporally well defined chemical stimuli to neurons to induce the formation of synapses [1]. For the first time this allow the determination of relevant times to signal cascades leading to the formation of functioning synapses [2]. We have furthermore succeeded in forming a synapse to an artificial structure – a suitably coated polystyrene bead attached to an AFM tip. Using rat neurons, suitable custom developed microfluidic systems and micro and nano tools we show that new, functional neurites can be created and precisely positioned to directly (re)wire neuronal networks [3]. We show that the adhesive contact made onto an axon or dendrite can be pulled to initiate a new neurite that can be mechanically guided to form new synapses at up to 0.8 mm distance in less than 1 h. The extension rates achieved is at least 60 times faster than previously reported 'natural' growth rates. Our findings challenge current understanding of the limits of neuronal growth and have direct implications for the development of new therapies and surgical techniques to achieve functional regeneration after trauma and in neurodegenerative diseases. It also opens the door for the direct wiring of robust brain-machine interfaces as well as investigating fundamental aspects of neuronal signal processing and neuronal function.

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References:

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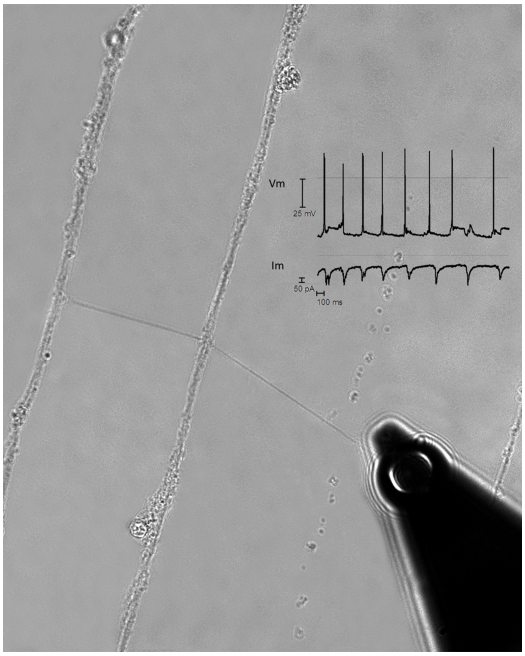
[3] M.H. Magdesian et al , J. Neuroscience **6**, 979 (2016)

Figure:



Live neurons reconnected by AFM manipulation. Double patch clamp demonstrate functionality.