Neurite Outgrowth on Nanomodified Surfaces

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We are engaged in an interdisciplinary effort aimed at the construction of a neural implant (chip) which could both listen and talk to the nervous system, that is both record neural activity and stimulate it. Such an implant must be biocompatible and survive in an environment hostile to foreign materials and electronics for years. It must also be small and possess a high spatial and temporal resolution. The potential market for this type of device is staggering considering that it can be used to compensate for neural deficits in both sensory and motor functions, e.g., hearing, vision and impaired mobility.

We have speculated that nanotechnology offers the possibility to modify neural implant surfaces in a manner that makes the implant biocompatible and attractive to neural growth. To this end we have investigated whether nanomodification of surfaces can be used to guide nerve cell processes, neurites, on intended chip surfaces.

We use primary cultures of the dorsal root ganglia, DRG, from mouse to study neurite outgrowth. The DRG, which contains sensory nerve cells, are removed from mice and mounted on chip surfaces which have been modified in a variety of ways. Outgrowth of neurites is then studied over several days either by electron microscopy or immunocytochemical staining of the neurites.

In this type of experiment we demonstrate that protein patterns generated by ink-jet printing on a chip surface were a simple manner to guide the outgrowth of neurites (1). We also demonstrate that making porous silicon by electrochemical etching provided another powerful way of guiding neurite outgrowth. In this type of experiment we found that neurites preferred pore sizes in the range of 200 - 500 nm (2). In other experiments in which nanopatterened surfaces were obtained by nanoimprint lithography we observed that neurites preferred to growth on sharp edges (3). We have also tested if GaP nanowires could be used for neurite guidance (4). This is important since such wires may be potential neural electrodes and may offer a means by which neural activity may be recorded at very high spatial resolution. We found that nanowires acted as guides and that isolated DRG nerve cells survived on nanowires, although the wires penetrated the neurons.

Taken together our results show that fairly simple nanomodifications of surfaces can be utilized to guide axons on chip surfaces (e.g. to hot spots like electrodes). We are currently investigating how such surfaces could also be used to increase the biocompatibility of neural implants.

1. Gustavsson et al, Biomaterials, 2007 (6) 1141.
2. Johansson et al, Phys Stat Sol, 2005 (29) 3258
3. Johansson et al, Biomaterials, 2006 (8) 1251.
4. Hällström et al, Nano Lett, 2007 (10) 2960.

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