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Conductive Polymer Scaffold Implant for Neural Stem Cell Tissue Engineering

Researchers in Prof. Paul George's laboratory have patented a conductive polymer scaffold designed to electrically stimulate neural progenitor cells (NPCs) for enhanced neural regeneration. The scaffold mimics the natural environment for growing NPCs and aids in transferring cells to regenerate damaged brain tissue, such as ischemic damage from a stroke. This biocompatible, electrically conductive polymer plate is attached to an implantable cannula system. It can be used to electrically stimulate neural stem cells in culture or directly in the brain, promoting paracrine signals that improve vasculature and endogenous stem cell production. This innovation combines electrical and chemical stimulation for neural recovery, enhancing neural regeneration and rehabilitation. The technology has applications in basic research and therapeutics, optimizing recovery from neural damage, especially stroke.

Stage of Research

The inventors have demonstrated the efficacy of the conductive polymer scaffold for preconditioning NPCs in vitro and stimulating cells in vivo:

In vivo studies - The inventors used the scaffold and cannula system to deliver NPCs and apply electrical stimulation in a rat model of occlusion stroke. They demonstrated that the system can enhance recovery and improve post-stroke functional outcomes.

In vitro preconditioning - The inventors used the scaffold to electrically stimulate NPCs 1 day prior to transferring the implant into the brain using a rat model of stroke. The preconditioned cells improved post-stroke neurologic function and had downstream effects on the host cortex.

Applications

- **Stem cell therapy for neural regeneration** - The conductive scaffold provides a stem cell niche to: pre-condition cells with electrical stimulation; transfer implant to brain for treatment; and stimulate the transplanted cells in vivo (via cannula) to treat conditions such as:
  - stroke
  - Alzheimer's disease or other neurodegenerative diseases
  - glioblastoma
- **Research** - scaffold for culturing NPCs in studies such as:
  - elucidating neuronal repair mechanisms to identify novel drug targets
  - understanding electrical modulation paradigms
  - determining factors that are essential for stroke recovery (such as VEGF-A)

Advantages

- **Enhances recovery:**
  - electrical stimulation of implanted NPCs restores function in rat models of stroke faster than unstimulated NPCs
  - specifically targets stem cell treatment to the region of interest
  - stem cells can target brain repair and have a therapeutic effect on the patient months or even years post-injury
- **Easier stem cell delivery and in vivo access:**
  - biocompatible polymer scaffold provides appropriate niche in vitro and enables entire implant assembly to be transferred from in vitro culture into brain
  - minimizes cell death and maintains electrical interactions after seeding
  - cannula design enables access to implant for electrical stimulation in vivo
- **Multimodal stimuli (electrical and chemical):**
  - stem cells trigger chemical cues for recovery, releasing paracrine factors directly onto the desired region
  - electrical stimulation increases endogenous stem cell production, further enhancing regenerative effects of stem cells
  - electrically preconditioned NPCs secrete increased amounts of VEGF-A which enhances changes in brain vasculature both near the implant and in

tissue further from the scaffold

Publications

- George, P. M., Bliss, T. M., Hua, T., Lee, A., Oh, B., Levinson, A., ... & Steinberg, G. K. (2017). Electrical preconditioning of stem cells with a conductive polymer scaffold enhances stroke recovery. *Biomaterials*, 142, 31-40. doi: 10.1016/j.biomaterials.2017.07.020.

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