

Engineering Approaches to Regenerating Damaged Neural Tissue

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Nerve regeneration is a complex biological phenomenon. In the peripheral nervous system (PNS), nerves can regenerate on their own if injuries are small. Larger injuries must be surgically treated, typically with nerve grafts harvested from elsewhere in the body. Thus, bioengineering strategies for the peripheral nervous system are focused on alternatives to the nerve graft, particularly for very large and clinically-relevant defects, and improving recovery rates and functional outcome. The central nervous system (CNS) is a greater challenge for new therapies, as there are factors in the body that inhibit repair. Unfortunately, a solution to completely repair spinal cord injury has not been found. The ability of spinal nerves to regenerate was not decisively shown until 1980, and it was not until after this time that research in this area rapidly developed. It has been shown that both embryonic spinal cord grafts and peripheral nerve tissue grafts can support regenerating fibers in the CNS, but the fibers often do not successfully grow back across the PNS-CNS transition zone. Thus, bioengineering efforts are focused on creating a permissive environment for regeneration and providing a seamless interface between the CNS and PNS. These challenges provide fertile ground for the development of therapies and devices to enhance regeneration. Many researchers are presently focusing efforts on creating physical or chemical pathways for regenerating axons. These devices include physical or mechanical guidance cues, cellular components, and biomolecular signals. Future therapies will incorporate multiple cues into unique devices that more closely mimic native nerve. They will also be interactive and programmable, and thus capable of seamless communication with surrounding tissues.