Regenerating Nerves
A polymer coated with chemicals that resemble a common neurotransmitter can stimulate the growth of neurons.

By Eric Bland
The human body can be amazingly resilient: wounds heal, bones mend, ligaments grow back together. But recovery from nerve damage is far less reliable. In the latest issue of *Advanced Materials*, researchers Christiane Gumera and Yadong Wang from the Georgia Institute of Technology announced that they have triggered the regrowth of nerve cells using a polymer coated with chemical structures that resemble acetylcholine, a common neurotransmitter. The research, which is the first to combine a neurotransmitter and a polymer, could one day lead to treatments for neurodegenerative diseases and spinal-cord injuries.

"Lots of people have done biopolymer work," says Christine Schmidt, a biomedical engineer at the University of Texas at Austin. "But this demonstrates that a polymer with a neurotransmitter can be used to guide growth in the nervous system."

Previous research has identified several agents that can stimulate the regrowth of nerve cells, or neurons, a protein called laminin foremost among them. But laminin is water soluble and dissolves quickly in the water-based environment of the body. The Georgia Tech researchers' material worked as well as laminin, but because it is water insoluble, it is more likely to stay in place if inserted into a patient's body, and it could stimulate the growth of nerve cells for weeks instead of days.

Acetylcholine, the neurotransmitter that the researchers concentrated on, is one of the most commonly occurring. Like all neurotransmitters, it carries, amplifies, and modulates signals sent between neurons. For years it has been known that acetylcholine stimulates the growth of a neuron's information-carrying projections, or neurites: the lone, long transmitter called the axon, and the many short receivers called dendrites. But the body's enzymes break apart acetylcholine less than a second after detecting it, since too much acetylcholine is toxic and inhibits neurites.

To give their acetylcholine-like chemical a controlled, long-term effect, the researchers attached it to a material that enzymes can't break apart: a flexible and biodegradable polyester. Wang notes that other chemical messengers can be attached to the polymer backbone, and that the whole assemblage breaks down after several weeks.

Wang and Gumera placed a small piece of rat nerve and its surrounding tissue on the polymer and measured nerve length over the next four to six days. The neurites grew steadily for six days, then began to slow down. The longest neurite produced was more than five millimeters long, with a maximum growth rate of 0.7 millimeters a day.

Wang and Gumera also tested materials in which their acetylcholine stand-in--known as an acetylcholine-like functional group--and the polymer were combined in different ratios. Neurite growth increased with the concentration of the functional group, up to 70 percent. Materials with concentrations of the functional group higher than 70 percent inhibited neurite growth. The researchers also tested the polymer against laminin, the "gold standard" for neurite growth, according to Wang, and the neurite growth induced by both materials was very nearly the same. Wang plans to begin work on a polymer with functional groups that mimic both acetylcholine and laminin, which he hopes will produce an even stronger effect.
Wang is also working to fabricate the polymer in configurations that would be more therapeutically useful. "Right now we just have a flat coating of polymer," he says. "What we are trying to do next is spin the polymer into nano- or submicrofibers."

Since the polymer is made out of polyester, manipulating it into other shapes should be a simple matter, says the University of Texas's Schmidt.

Under the right circumstances, injured neurons are capable of some regeneration, but scar tissue inhibits their growth. Wang, who has been working on the polymer research for more than three years, thinks that one day surgeons could thread fibers of a polymer studded with growth promoters through scar tissue, guiding neurites to an environment where they can continue to grow of their own accord. "Once you reach the proper environment, it will make the neuron grow very well," he says. A few millimeters of the fiber inserted surgically would be enough to overcome the repulsing effects of scar tissue.

To treat neurodegenerative diseases like Alzheimer's, Wang hopes to use the polymer to more efficiently generate neurons that could be transplanted into patients.

Any therapeutic use of the neurotransmitter-mimicking polymer, however, is still years away. "Designing new materials with different functionalities is tough," says Schmidt. "But this could lead to new results. There is a lot of potential."

Copyright Technology Review 2007.