Society for Biological Engineering
An AIChE Technological Community
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Making Tissue Regrowth and Repair a Reality

The ability to regenerate organs, ligaments, or other tissues sounds like something straight out of a comic book, but regenerative engineering has the potential to give us this super power.

Researchers at the National Institute of Diabetes and Digestive and Kidney Diseases have made huge strides in the regeneration of functioning kidneys in rats. They were able to regrow functioning kidney tissue *in vivo* and *in vitro* that absorbs nutrients and generates urine by seeding a scaffold made of collagen from organ donors with endothelial and epithelial cells.

A tissue engineer at the National Institute of Biomedical Imaging and Bioengineering created a gel that can be injected into the knee to promote cartilage regeneration. Cartilage is harder to repair than other tissues because blood does not flow to it. During microfracture knee surgery, surgeons drill small holes into the bone to allow blood to flow to the cartilage, but this method only has a 50% success rate. Combining the gel injection with an adhesive improved cartilage growth in clinical-trial patients.

The axolotl, a salamander that can regenerate entire limbs, has long been studied for its ability to self-heal. It has recently been discovered that a type of white blood cell called a macrophage is present in the early stages of the axolotl's regeneration cycle. When the macrophages are removed from the wound sites, the axolotl loses its regeneration ability and tissue scarring occurs. This discovery sheds light on how humans might be able to regrow tissue and self-heal.

These examples show the exciting potential of regenerative engineering, which seeks to combine techniques from multiple disciplines to promote and advance the regrowth of tissues and organs within the body. Regenerative engineering is a broad field that encompasses tissue engineering, stem cell engineering, and developmental biology, among others. Using tissue-engineering principles as a foundation, regenerative engineering expands existing methods by introducing new and innovative ideas.

Tissue engineering got its start in the study of biomaterials to help promote tissue regrowth. To nurture the environment for growth, cells need an extracellular matrix, which acts as a support for the proliferating cells. The combination of artificial scaffolds with live cells creates structures that help preserve tissue as well as promote proliferation of cells to repair damaged tissue.

One of the main focuses and challenges in tissue engineering is developing the scaffold. Hydrogels such as polygalacturonic acid (PGA) are often used to construct scaffolds because they are mechanically sound and porous, which enables multiple cells to be seeded and provides a pathway for nutrients to stimulate cell growth. Hydrogels have the advantage of being biodegradable within the body. Scaffolds can also be created from tissue from donor organs, which are less likely to incur an immune response.

While the scaffold provides support for the cells to grow, the type of cells secreted within the scaffold is just as important to the success of the regeneration. Cells may be allogeneic, from a foreign donor; autogenic, from the patient's own body; or xenogenic, from a (non-human) animal. Because allogeneic and xenogenic cells are not an exact match to the patient's cells, they are subject to immune attacks once inside the host. While autogenic cells are better suited to handle the immunoresponse, quantities are limited because they can only be harvested from the host's own body.

Pluripotent stem cells, which have the potential to differentiate into virtually every cell type, are being studied as an alternative option. A focus of stem cell research is determining the biochemical signals that control stem cell development into various cell types. Pluripotent stem cells, however, are a very limited resource and are not easily harvested.

Researchers have experimented with a variety of methods to combine scaffolds and cells. In some cases, cells are mixed with the scaffold all at once and the cells are allowed to grow. In other cases (such as in the example of regenerating kidney tissue in rats), cells are removed from a donor tissue sample, leaving only the collagen scaffold behind; the scaffold is then seeded with a variety of new cells and sometimes growth factors.

Regenerative engineering does not focus on any one of these specific research areas, but rather integrates them. The primary objective of regenerative engineering is implementing novel and innovative solutions into viable clinical applications.

AIChE has created the Regenerative Engineering Society to promote and advance regenerative engineering. The society held its first annual Rock Stars of Regenerative Engineering conference in December 2016 in Irvine, CA. The next Rock Stars of Regenerative Engineering event is planned for June 2017 in Boston, MA. Visit www.aiche.org/resociety to learn more about the Regenerative Engineering Society. CEP