http://itotd.com/articles/430/printing-skin-tissue/

January 15, 2005

Printing Skin Tissue

Human organs from 3-D printers

An earlier article here covered 3-D printers, which use modified inkjet technology to create solid objects with extremely complex shapes. The printers use a variety of techniques to solidify arbitrary areas on the surface of a powdered substrate, which supports the object as it is built up layer by layer. Designers commonly use 3-D printers for prototyping things like consumer electronic products, ensuring that they will be manufacturable before expensive metal molds are created to enable mass production. I ran into an old acquaintance the day that article ran who had never heard of Interesting Thing of the Day, so I told him about the site. He asked me what that day's topic was, and I happily described the 3-D printers. He said, "Oh yeah, I know about those. Did you know they're also using them to 'print' human tissue?" Um…no, I had no idea. It turns out that the humble inkjet printer has quite a few tricks up its sleeve—including, incredibly, the capability of manufacturing living skin and other organs.

Cell Mates

Growing individual human cells is not especially difficult. Take a sample of healthy cells, provide them with the right nutrients and environment, and they will grow and multiply. When multiple tissue cells are placed in close proximity to each other, they have a tendency to fuse together. Because of this phenomenon, hospitals can "grow" new skin to be used as grafts for burn patients using the patient's own skin cells. However, this technique does have significant limitations. In particular, the skin cannot be made very thick because there's no way to get blood to deeper cells—the process grows a homogeneous sheet of skin without the essential network of blood vessels, not to mention pores and other minute structures.

But creating intricate solid structures layer by layer is easy for a 3-D printer. So researchers have adapted old inkjet printers to hold a suspension of human cells in one reservoir and a gel-like substrate in another. Each pass of the print head lays down a pattern of cells held in place by the gel; when the next layer is applied, the adjacent cells begin to fuse to the layer beneath. If, for example, each layer contains a circle of cells in the same location, the result will be a tube—in other words, a structure very much like a blood vessel. A printer could in fact hold different kinds of cells in an array of ink reservoirs (like those used by color printers), theoretically enabling the creation of entire organs.

It's All Beginning to Gel

The gel that functions as the substrate for this type of tissue printing is itself quite interesting. As with the powdered material used in rapid prototyping, the gel must be removed after the rest of the structure has solidified. Called thermo-reversible gel, it has the unusual property of being solid above 32°C and turning into a liquid when cooled below 20°C. So after the cells have fused, the tissue is cooled and the liquefied gel simply drains away.

Although the most obvious application for such a technology is producing skin grafts that are more robust than what's currently possible, one day much thicker organs could be printed—making the inkjet printer a veritable tool for manufacturing replacement human parts. But although early laboratory experiments have yielded impressive results, researchers caution that the technology is in its infancy—likely a decade or more away from even initial trials with real patients. One of the hurdles to be overcome is that cells take time to fuse together into tissue, but can only survive for a short period of time without nutrients and oxygen. So the thicker a printed organ is, the more difficult it will be to keep it alive and healthy until the gel can be removed and it can begin getting nourishment from blood (or a reasonable facsimile thereof). Furthermore, remember that the printers don't actually create the cells; they only arrange them. All the cells must have been grown in advance, a process that can take weeks (and that cannot be done equally well with all types of cells). So don't expect to show up at the emergency room and get a new pancreas printed while you wait. —Joe Kissell