Biohybrid Organs

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All people face the reality that one day we will lose the race of life to an unbeatable foe called age. As people age, their bodies obviously begin to break down. But, in simplest terms, the body is mainly just a system that runs by electrical impulses and chemical gradients. So is it impossible to make replacement parts for the aging body, much like a computer or automobile?

Most certainly not. Biohybrid, or bioartificial, organs combine living cells with materials such as silicon and polymers. The inorganic material creates the structure of the organ while the living tissue does the complex tasks that they were initially meant to do. The tissues are currently grown from cadavers and animals, but researches are aiming towards growing tissue from the patient's own body.

A majority of the newest products involve semiconductor fabrication techniques. This involves growing cells in specifically ordered arrays on chips made of semiconductor material. Electrical impulses then pattern the cells as they would be in a natural organ, and stimulate them appropriately so they develop into the needed tissues.

Because the relative simplicity of the kidney's blood filtering function, added to the demand for them, makes them most likely to be the first biohybrid organs available. The most advanced treatment today for acute kidney failure is an experimental renal assist device (RAD), developed by H. David Humes, U. Michigan. It is currently in its second of three phases of clinical trials. It is a device that can be attached to a bedside dialysis machine, and contains human *proximal renal tubules*, or cells that normally recover useful chemicals from the fluid that remains after the blood has been strained through the glomeruli, or the kidney's first line of filters. The cells in the renal proximal tubules scavenge glucose and salts from the filtered fluid and return them to the blood. The cells from the tubules also seem to help the immune system fight off systemic infections. The RAD is designed to mimic all of these actions. William H. Fissell, a nephrologist working with Humes, is growing renal proximal tubule cells on silicon chips to create a device so the RAD may become implantable. One major challenge is being able to create something small enough that can be implanted in someone's body, but large enough to filter the 180L of blood processed each day by our two kidneys.

Dr. Boerenstein of Draper Labs is currently trying to beat this problem, with his prototype kidney system, which is described as a micro fluidic device with an area of $15cm^2$ and is about 1mm thick. His device mimics the structure of the glomeruli, and consists of two planar sheets of plastic etched with microchannels and separated by a special polymer based filtration membrane. As the blood goes through the microchannels in the top sheet, the waste products pass through the membrane into the microchannels of the bottom sheet. This process can be amplified by adding layers, where the final devices might need hundreds or thousands of layers. In his tests, he showed that the device could remove creatinine and urea from blood samples, which are two of the three major waste products filtered by the kidneys. Next, Borenstein plans to incorporate renal proximal tubule cells into his device, and attaching the whole device to the circulatory system, possibly at the wrist, being driven by the body's own blood pressure.

A great deal of time and effort is being put into this area, and it is said that a final device might be seen on the market in as few as five years from now.