Developing an Artificial Kidney

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Nearly 500,000 Americans depend for their lives on thrice-weekly, in-clinic kidney dialysis to remain alive. The treatment is costly ($23 billion a year or about $46,000 per person), very demanding, and provides only a low quality of life. Some 80,000 Americans are on waiting lists for kidney transplants, with 4,000 dying each year before they get one. A steadily operating, ambulatory blood purification system would decrease patients' burdens and increase quality of life for all of these patients. At present no ambulatory blood processing system exists. Dialysis patients are particularly affected by water accumulation over the typical two-day interval between treatments and thus often experience wide, dangerous, and uncomfortable swings in blood pressure.

Edward Leonard and his team have been working with government and investor support to devise a water extractor for these patients, and also for heart patients who accumulate water. The device, smaller than a lemon, spreads flowing blood into a layer only 100 microns thick. This layer passes between two thin sheets of silicon nitride perforated with many millions of precisely formed nanopores. Cell-free blood plasma is collected from the pores, is processed to extract water, and then is returned along with the cells to the patient. Blood cells move quickly and contact the filter for less than a second. The device, together with the plasma processor, two pumps, and a battery is expected to be about 4 inches square and 1 ½ inches high. It is designed to be worn by the patient at all times, removing water slowly and nearly continuously. This novel blood-cleansing system will not require anticoagulants and will keep treatment costs well within current, federally-mandated cost-containment limits for kidney patients. Testing is underway and first trials on patients are expected in 2013.

Leonard directs Columbia's Artificial Organs Research Laboratory, a component of the Department of Chemical Engineering since 1968. Its mission has grown with the evolution of modern biology and with the increasing sophistication available for the construction of medical devices. Thus, current projects have a wide range: innovations to traditional artificial organs effecting transport (kidney, liver, lung, cardiovascular implants) with special emphasis on the artificial kidney, to regenerative medicine, especially the development and study of methods for introducing stem cells into adult tissue. Leonard, who directs the NSF-sponsored course cluster in Genomic Engineering and is a member of the Columbia Genome Center, is one of the first Columbia Engineering faculty members to engage in bioengineering research. He has worked in the dialysis field for more than 50 years and has been on the Columbia faculty since 1958. His principal medical collaborator is Dr. Stanley Cortell, professor of clinical medicine and chief of nephrology at St. Luke's-Roosevelt Hospital.

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