THE ARTIFICIAL RETINA PROJECT

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The DOE (The U.S. Department of Energy) Artificial Retina Project is a multi-institutional collaborative effort to develop and implant a device containing an array of microelectrodes into the eyes of people blinded by retinal disease. The ultimate goal is to design a device with hundreds to more than a thousand microelectrodes. This resolution will help restore limited vision that enables reading, unaided mobility, and facial recognition.

The device is intended to bypass the damaged eye structure of those with retinitis pigmentosa and macular degeneration. These diseases destroy the light-sensing cells (photoreceptors, or rods and cones) in the retina, a multilayered membrane located at the back of the eye.

Normal vision begins when light enters and moves through the eye to strike specialized photoreceptor (light-receiving) cells in the retina called rods and cones. These cells convert light signals to electric impulses that are sent to the optic nerve and the brain. Retinal diseases like age-related macular degeneration and retinitis pigmentosa destroy vision by annihilating these cells.

With the artificial retina device, a miniature camera mounted in eyeglasses captures images and wirelessly sends the information to a microprocessor (worn on a belt) that converts the data to an electronic signal and transmits it to a receiver on the eye. The receiver sends the signals through a tiny, thin cable to the microelectrode array, stimulating it to emit pulses. The artificial retina device thus bypasses defunct photoreceptor cells and transmits electrical signals directly to the retina's remaining viable cells. The pulses travel to the optic nerve and, ultimately, to the brain, which perceives patterns of light and dark spots corresponding to the electrodes stimulated. Patients learn to interpret these visual patterns.

The DOE project is built on the foundational work of its leader, Mark Humayun at the Doheny Eye Institute of the University of Southern California. In a breakthrough operation performed in 2002, the team led by Humayun successfully implanted the first device of its kind — an array containing 16 microelectrodes — into the eye of a patient who had been blind for more than 50 years. Since then, more than 30 additional volunteers around the world have had first- or second-generation (60-electrode) devices implanted. These devices enable patients to distinguish light from dark and localize large objects.

Three models in testing and development are:

Model 1 (Argus™ I). The Model 1 device was implanted in six blind patients between 2002 and 2004, whose ages ranged from 56 to 77 at time of implant and all of whom have retinitis pigmentosa. The device consists of a 16-electrode array in a one-inch package that allows the implanted electronics to wirelessly communicate with a camera mounted on a pair of glasses. It is powered by a battery pack worn on a belt. This implant enables patients to detect when lights are on or off, describe an object's motion, count individual items, and locate objects in their environment. To evaluate the long-term effects of the retinal implant, five devices have been approved for home use.

Model 2 (Argus™ II). The smaller, more compact Model 2 retinal prosthesis is currently undergoing clinical trials to evaluate its safety and utility. This model is much smaller, contains 60 electrodes, and surgical implant time has been reduced from the 6 hours required for Model 1 to 2 hours.

Model 3. The Model 3 device, which will have more than 200 electrodes, has undergone extensive design and fabrication studies at the DOE national laboratories and is ready for preclinical testing. The new design uses more advanced materials than the two previous models and has a highly compact array. This array is four times more densely packed with metal contact electrodes and required wiring connecting to a microelectronic stimulator. Simulations and calculations indicated that the 200+ electrode device should provide improved vision for patients.

Other retinal prostheses projects are under way in the United States and world-wide, including Germany, Japan, Ireland, Australia, Korea, China, and Belgium. These programs pursue many different designs and surgical approaches. Some show great promise for the future, but have yet to demonstrate practicality in terms of adapting to and lasting long-term in a human eye.

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