

The U.S. Department of Energy's Artificial Sight Program

Cole DA¹, Viola MV¹, Yow, L², Humayun, MS², Weiland, JD²,
Greenberg R³, and Greenbaum E⁴

¹ Medical Sciences Division, U.S. Department of Energy, Washington, DC 20585 USA

² Doheny Eye Institute and USC Health Sciences Center, Los Angeles, CA 90033 USA

³ Second Sight Medical Products, LLC, Sylmar, CA 91342

⁴ Chemical Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831 USA

E-Mail: greenbaum@ornl.gov

Abstract

This talk will provide an overview of the U.S. Department of Energy Medical Sciences Division's program on artificial sight. The program comprises a team effort of multiple DOE national laboratories, research universities and a private sector corporation. By means of a unique team approach, key problems in the science and engineering of developing retinal prosthetic implants as visual aids to people who are blind due to age-related macular degeneration or retinitis pigmentosa are being pursued. The scope of research includes the physics and chemistry of neurophysiology, materials science, biomedical engineering and frontier ophthalmologic surgical techniques.

1. INTRODUCTION

Blindness: A Growing Problem

Sight loss can be devastating. And yet, almost 10 million people with blindness or visual impairments face this challenge every day, a number roughly equal to the population of Michigan.

As America's population ages, the number of



people with vision impairments is increasing. In a 1998-2000 publication, Prevent Blindness America predicted that *twice* as many people will be blind in 2030 as there are today.

In addition to the increasing social impact, vision impairment also takes its toll on the U.S. economy: \$4 billion are lost each year in benefits and taxable income.

Two major causes of blindness, age-related macular degeneration (AMD) and retinitis pigmentosa (RP), damage the photoreceptor cells in the light-sensitive membrane in the eye (retina) but leave the nerve connections to the brain intact. Patients eventually lose their vision.

2. METHODS

DOE's Unique Resources

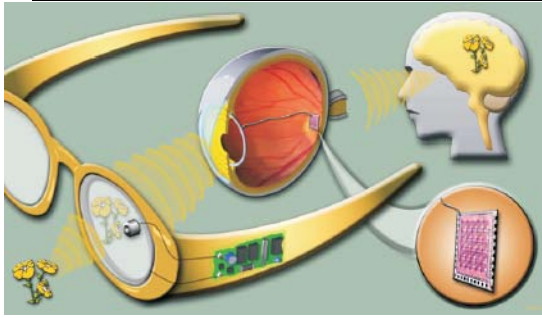
The artificial retina projects are collaborative efforts that exploit the unique multidisciplinary resources of the DOE national laboratories in materials sciences, microfabrication, micro-electrode construction, photochemistry, and computer modeling. BER support for this project grew dramatically as opportunities for technical breakthroughs arose. It is anticipated that newer models of implants will have higher resolution and someday can allow patients to read, watch television, and recognize faces. A product that can be distributed to patients suffering from retinal degenerations could be available within the next five years.

3. RESULTS

Potential Solution: An Artificial Retina

Scientists funded by the U.S. Department of Energy (DOE) Biological and Environmental Research (BER) program are developing a prototype artificial retina that could help provide a solution for this growing challenge. Ultimately, the goal is to restore useful vision for patients blinded by AMD and RP.

This work builds upon a first-generation device containing a 16-electrode array on a miniature disc that can be implanted in the back of the eye to replace a damaged retina.



The implant has pieces both inside and outside the eye. Patients wear glasses, like those shown at left, with a tiny camera embedded in the lens. The camera captures images and sends the data to a micro-processor (concealed in the side of the glasses) which converts the data to an electronic signal. An antenna in the lens transmits the signal to a receiving antenna in the eye. The signal then travels along a tiny wire to the retinal implant. The signal causes the implant to stimulate the remaining retinal cells which send the image along the optic nerve to the brain.

In the spring of 2002, a Food and Drug Administration approved prototype device was implanted into the eyes of six blind people as part of a limited clinical trial conducted by Doheny Eye Institute (University of Southern California, Los Angeles) and Second Sight Medical Products, LLC (Sylmar, California). Patients can now distinguish light from dark and can see shapes. BER is supporting development of the next-generation artificial retina a 1000-array micro-electrode capable of restoring limited vision. using materials that will last for a lifetime.

Research Team

Developing an artificial device that can survive in the eye's saline environment and perform complicated tasks presents many obstacles. To meet this challenge, DOE has established a multidisciplinary coalition:

- Argonne National Laboratory, Argonne, Illinois
- Lawrence Livermore National Laboratory, Livermore, California
- Los Alamos National Laboratory, Los Alamos, New Mexico
- Oak Ridge National Laboratory, Oak Ridge, Tennessee
- Sandia National Laboratories, New Mexico and California
- Doheny Retina Institute, University of Southern California, Los Angeles, California
- North Carolina State University, Raleigh, North Carolina
- Second Sight, Medical Products LLC, Sylmar, California
- University of California, Santa Cruz

4. DISCUSSION AND CONCLUSIONS

Department of Energy

For the past 55 years the Department of Energy (and its predecessor agencies) Office of Science has been in the forefront of imaging sciences, from clinical imaging in nuclear medicine, a field founded by DOE, to imaging atoms at the DOE synchrotron light sources. The Office of Biological and Environmental Research has taken a leadership role in developing molecular tracers, advanced instrumentation (e.g., PET scanners, digital cameras, high-resolution detectors), and computational systems for rapid processing of imaging data that are used worldwide in hospitals and research laboratories.

The Office of Biological and Environmental Research's Advanced Biomedical Technology Program supports multidisciplinary, multi-institutional projects that address daunting medical technology challenges. The projects ultimately will lead to the development of medical instruments and techniques that can be transferred to the National Institutes of Health for clinical testing or to industry for further development.