

USC Dr. Allen and Charlotte Ginsburg Institute for Biomedical Therapeutics



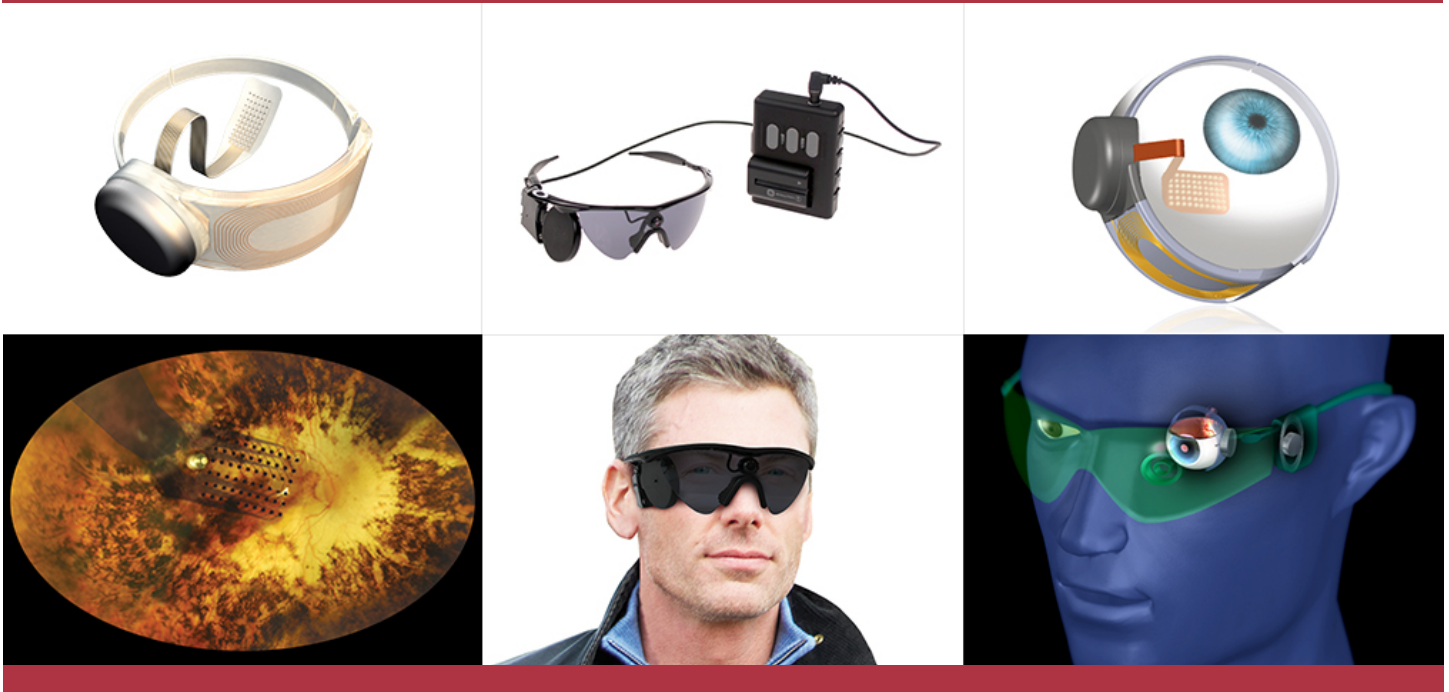
President Barack Obama presented the National Medal of Technology and Innovation to Mark Humayun, MD, PhD, at the White House on May 19, 2016.

President CL Max Nikias and Mark Humayun discussing Argus II development (USC Photo/Steve Cohn)

USC Ginsburg IBT Global Initiative

Working at the interface of medicine and engineering, IBT's vision is to transform bioengineered neural interfaces into treatments for patients for whom there is currently no foreseeable cure. Using an interdisciplinary approach, our mission is to further our basic understanding of debilitating neurosensory disorders, ultimately leading to the development of novel diagnostic and treatment options.

Neural Electronics: The Argus II Retinal Prosthesis



The Invention

As both an ophthalmologist and biomedical engineer, Dr. Mark Humayun assembled a team of world experts to create a revolutionary device, known as the Argus II retinal implant for those suffering from an inherited form of blindness called retinitis pigmentosa (RP). It is the world's first FDA approved artificial retina system, which offers an unprecedented degree of sight to those with complete retinal blindness. This translational success story resulted in an interdisciplinary convergence of physicians, engineers, scientists, industrialists, the regulatory body as well as the patients who participated in the study that helped advance science. The device brings hope and represents the ability to restore sight to patients who have been blind for decades for whom there was no foreseeable cure.

The Technology

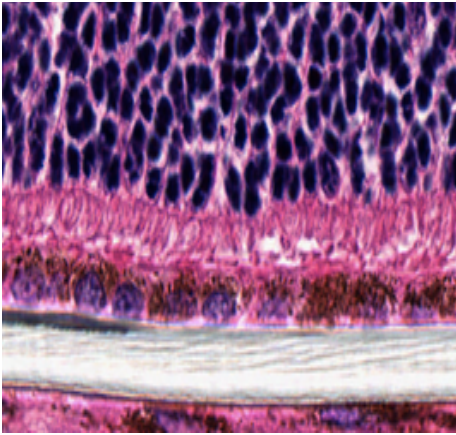
The Argus II device is a 60 electrode retinal prosthesis that captures images by an eyeglass-mounted camera, which sends wireless signals to the implanted chip. Once transmitted to the retina (light sensing and image processing part of the eye), the signal is carried to the optic nerve (the nerve connecting the eye to brain) and translated into an image. The results of the Argus II device, as outlined in a paper titled, "Long-Term Results from an Epiretinal Prosthesis to Restore Sight to the Blind," highlighted 30 subjects implanted with the Argus II at 10 centers throughout the United States and Europe. Of the 30 subjects tested 29 remained implanted with functioning Argus II at 3 years post-implant. Results showed that the Argus II system improved in visual function and orientation and mobility were maintained up to 3 years. Up to 89% of the subjects performed statistically better with the Argus II system implanted compared with native residual vision and visual function tasks at 3 years.

The Impact

This device has been implanted worldwide in more than one hundred patients after FDA approval. The company, Second Sight Medical Products, is working on the next generation of the implant, which will offer a higher resolution retinal implant with 240 electrodes and a cortical 60-electrode implant. Improving the resolution of Argus II to allow face recognition and reading vision as well as increase our understanding of color vision are currently being explored. To learn more about Argus II please visit: <http://ibt.usc.edu/ni-neural-electronics/>.

Scientific Frontiers: Neural Interfaces

Neural Scaffolds



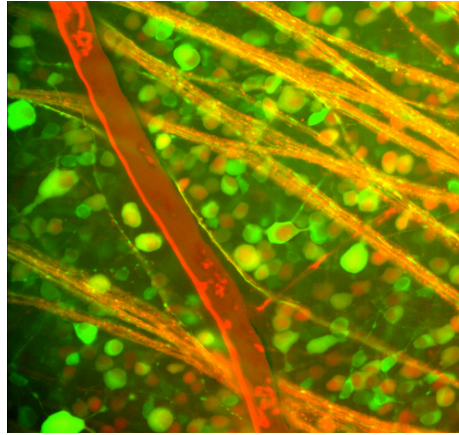
RPE seeded scaffold (white) implanted in the subretinal space

Synthetic Cellular Stem Cell Scaffolds

Age related macular degeneration (AMD) affecting over 2 million people in America, is a retinal disease that can lead to catastrophic vision loss. AMD affects central vision that results in the inability to read, recognize faces, or even drive. The disease leads to the death of photoreceptors caused by the loss of crucial retinal pigment epithelial (RPE) cells, which provide support and nutrition.

Both Drs. David Hinton, Humayun and their team are leading a stem cell phase I/IIa clinical trial for the treatment of AMD, awarded nearly \$38 Million through California Institute for Regenerative Medicine's (CIRM). A unique procedure was developed by which stem cell derived RPE cells are grown onto a synthetic scaffold implant. Thus, the critical photoreceptors needed for vision may be replenished by replacing diseased RPE tissue.

Neurophotonics



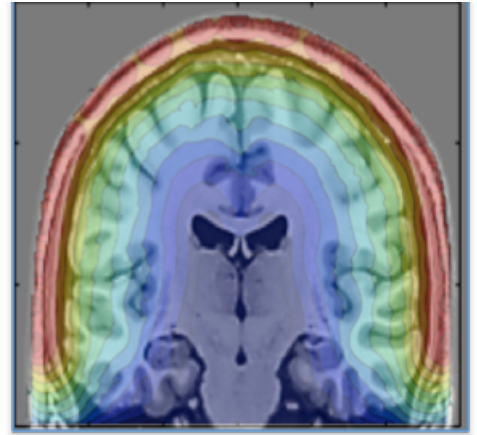
Ganglion cells in rat retina labeled with green and red probes

Treatments through Light Activation

In certain eye diseases, neurons that are responsible for vision, such as light sensitive photoreceptor and retinal ganglion cells, may become damaged and inactive. The creation of neurophotonic systems that act as nanophotoswitches, or tiny devices implanted in the eye, have been developed to treat these eye diseases by inducing normally non-photosensitive neurons to be able to respond to light. The novel photoswitches have the potential to significantly expand the power of neuroprosthetics.

In addition, in tandem with the NeuroRx group, IBT researchers have designed a new class of optically activated compounds. These "caged" compounds may be released once activated by infrared light. The novel caged compounds will augment the power of prosthetic devices, which may be used to restore vision to patients who are blind.

NeuroRx



Light activation of the brain

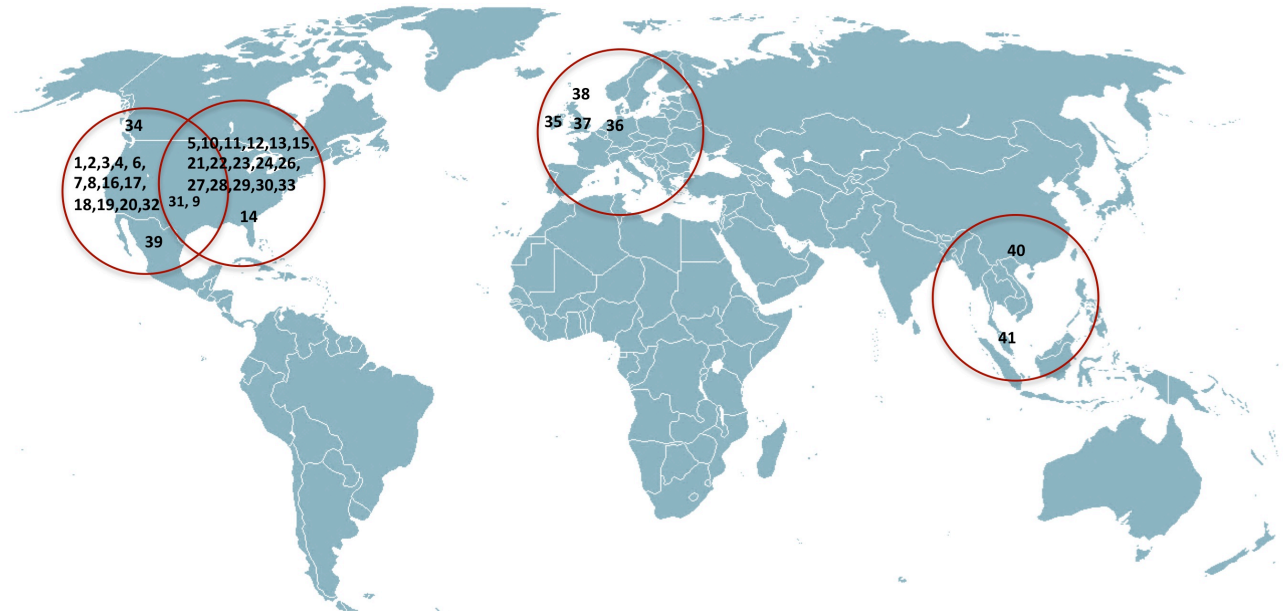
Drug Delivery Systems

This area focuses on novel drug delivery systems and bioelectronic implants that may deliver drugs across the blood-brain barrier in a highly selective manner. Novel micro and nanoelectromechanical systems, known as MEMS or NEMS, have been developed. The technology has been applied to MEMS based drug delivery systems.

This innovative bioengineering invention, along with the photoactivatable caged compounds, offer drug delivery systems that will revolutionize the field of neuropharmaceuticals.

The implementation of NeuroRx Therapies can be used to treat conditions such as dry and wet forms of AMD, uveitis, glaucoma, traumatic brain injury, and neurodegenerative diseases (e.g. multiple sclerosis).

An Interdisciplinary Approach



- | | | | |
|--------------------------|---------------------------|----------------------------|---|
| 1. USC | 12. Eli Lilly | 22. Blackrock Microsystems | 34. Cooledge |
| 2. CSULA | 13. Virginia Technologies | 23. NeuroNexus | 35. X-Celeprint |
| 3. Caltech | 14. Premitec | 25. MicroProbes | 36. MST |
| 4. UCSF | 15. Boston Scientific | 26. CellTraffix | 37. Morgan Technical Ceramics |
| 5. Uni of Illinois | 16. Second Sight | 27. Bausch & Laumb | 38. GlaxoSmithKline |
| 6. Replenish | 17. Advanced Bionics | 28. Semprius | 39. Tecnologico de Monterrey |
| 7. CamTek LLC | 18. Materia | 29. PDT | 40. Shenzhen Institutes of Advanced Technology (SIAT) |
| 8. Pt Group Coatings LLC | 19. Calhoun Vision | 30. NOCO | 41. Singapore Institute of Neurotechnology (SINAPSE) |
| 9. Alcon | 19. Fluid Synchrony | 31. Texas Instruments | |
| 10. Medtronic | 20. Syntouch | 32. Iridex | |
| 11. Synergetics | 21. MC10 | 33. SlimStim | |

USC IBT is a broadly interdisciplinary institute, involving four USC schools (Keck School of Medicine of USC, USC Viterbi School of Engineering, USC Dornsife College of Letters Arts and Sciences and USC School of Pharmacy), USC Roski Eye Institute and 14 distinct disciplines—including biomedical engineering, medicine, materials engineering, biology, biochemistry, biophysics, chemistry, pharmacology, physiology, and electronics—all of which share their unique insights at the discovery phase. Our work is complementary and synergistic, with a strong focus from the beginning on translational medicine. For more information please visit: ibt.usc.edu.

Innovation at the Interface of Academia and Industry

The relationship between USC IBT and its partners propels research forward, bringing us one step closer to translating our basic science discoveries into real clinical applications.

- Approximately \$14 million in additional collaborative grants and sponsored programs have been captured
- 199 patents have been filed
- 25 licensing agreements have been issued
- 10 new start-up companies have been founded

Keck School of
Medicine of USC

USC Roski Eye Institute
Keck Medicine of USC

USC Viterbi
School of Engineering

USC Dornsife
Dana and David Dornsife
College of Letters, Arts and Sciences

USC School
of Pharmacy

USC Ginsburg Institute