NASA Stanford Vision Chip

"Development of an implantable device consisting of an array of carbon nanotubes on a silicon chip for restoration of vision in patients with macular degeneration and other retinal disorders"

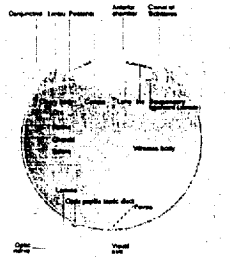
Carbon Nanotube Bucky Paper for Retinal Cell Transplantation

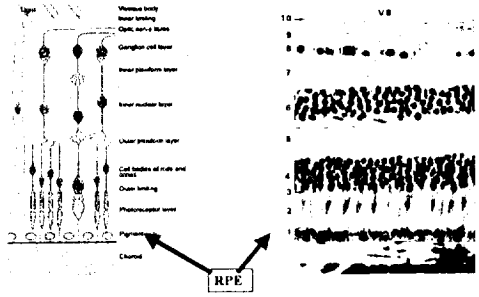
"A meshwork of carbon nantotubes as a substrate for retinal cell growth and as a 'carrier' to facilitate surgical transplantation of retinal cells into the retina of patients with macular degeneration"

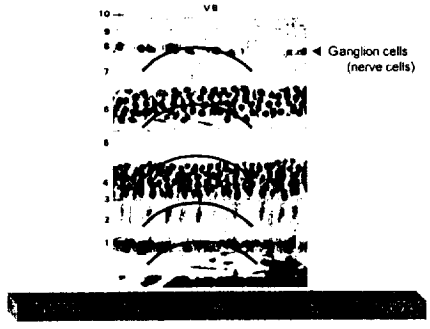
What is macular degeneration?

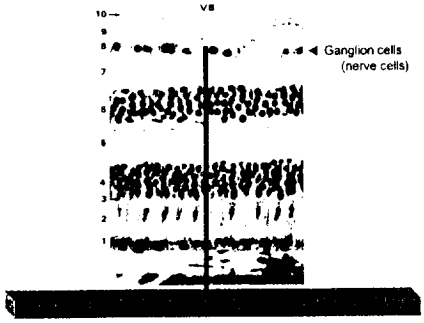
Age Related Macular Degeneration

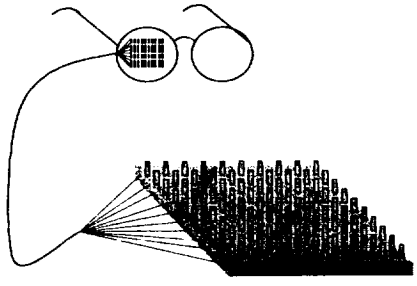
- Loss of central vision, due to the death of retinal pigment epithelium (death of photoreceptor cells)











NASA/Stanford Vision Chip

This project focuses exclusively on issues related to the interface with the retinal tissue, and does not involve work with CCD chips.

Hurdle #1: To demonstrate biocompatibility of carbon nanotubes in intact retinal tissue.

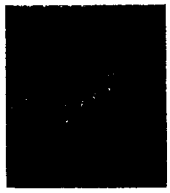
Hurdle #2: To demonstrate that carbon nanotube towers have sufficient mechanical strength to penetrate retinal tissue.

Hurdle #3: To demonstrate the ability of carbon nanotubes to convey electrical signals to the retinal ganglion cell layer.

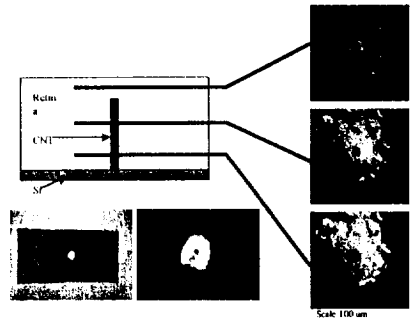
Preliminary Biocompatibility Data

Carbon Nanotube Tower on a Silicon Chip

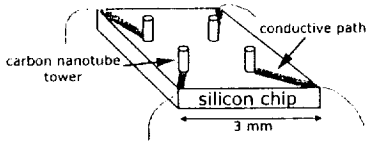
Tower consists of a bundle of multi-walled carbon nanotubes



Hurdle #1: Tissue Biocompatibility
Hurdle #2: Mechanical Strength



Hurdle #3: Electrophysiology Testing



Electrophysiology testing will consist of retinal tissue stimulation by the "Quad Chip," with recording of electrical activity in the ganglion cell layer adjacent to the CNT towers.

NASAStanford Vision Chip
High Risk/High Payoff Technology

Hurdle #1: CNT's are biocompatible

Hurdle #2: CNT towers have sufficient mechanical strength to penetrate retinal tissue.

Hurdle #3: Can CNT towers convey electrical signals to retinal ganglion cells?

Retinal Cell Transplantion

- In the early stage of macular degeneration, retinal pigment epithelial (RPE) cells die, which leads to loss of photoreceptors. Solution?—replace the cells that are lost.
- RPE cells and iris pigment epithelial (IPE) cells can be harvested from the eye, grown in culture, then put back into the eye ("autologous transplantation").

Problems with Retinal Cell Transplantation:

- Transplantation of suspensions of epithelial cells into the sub-retinal space fails to re-establish the proper architecture of the RPE layer. Instead of a sheet of uniformly oriented cells, you get a "jumble" of cells.

Solution:

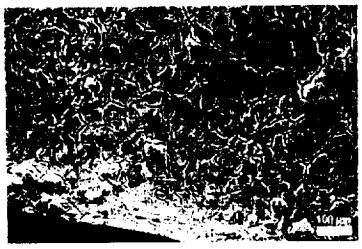
- Establish the proper orientation of the epithelial cells prior to transplantation, by growing them in culture on a physical support: ***Carbon Nanotube "Bucky Paper"***

Carbon Nanotube Bucky Paper

A meshwork of bundles of CNT's

Low-resolution Scanning Electron Micrograph of Carbon Nanotube Bucky Paper

Scanning Electron Micrograph of RPE cells grown On Carbon Nanotube Bucky Paper

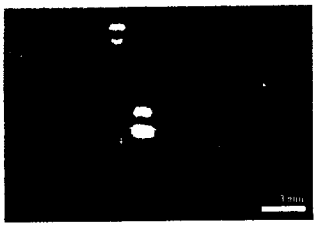


Result: Confluent monolayer, with uniform orientation of cells

Light Micrograph/Histological Staining of RPE Cells Grown on Carbon Nanotube Bucky Paper

Result: Excellent attachment of RPE cells to the Bucky Paper surface; confirmation of correct apical/basolateral orientation

Implantation of Carbon Nanotube Bucky Paper into the Sub-Retinal Space of an Albino Rabbit



Result: Bucky paper is easily manipulated during surgery (does not tear and stays flat), and is immunologically well-tolerated by the eye

Carbon Nanotube Bucky Paper for Retinal Cell Transplantation Summary:

Hurdle #1: Cellular Biocompatibility—RPE and IPE cells can be grown on CNT Bucky Paper.

Hurdle #2: Mechanical suitability—Bucky Paper can be successfully implanted surgically.

Hurdle #3: Tissue Biocompatibility—No signs of rejection in short tissue implantation studies.

Hurdle #4: Long-term Tissue Biocompatibility—Is CNT Bucky Paper suitable for permanent implantation?

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