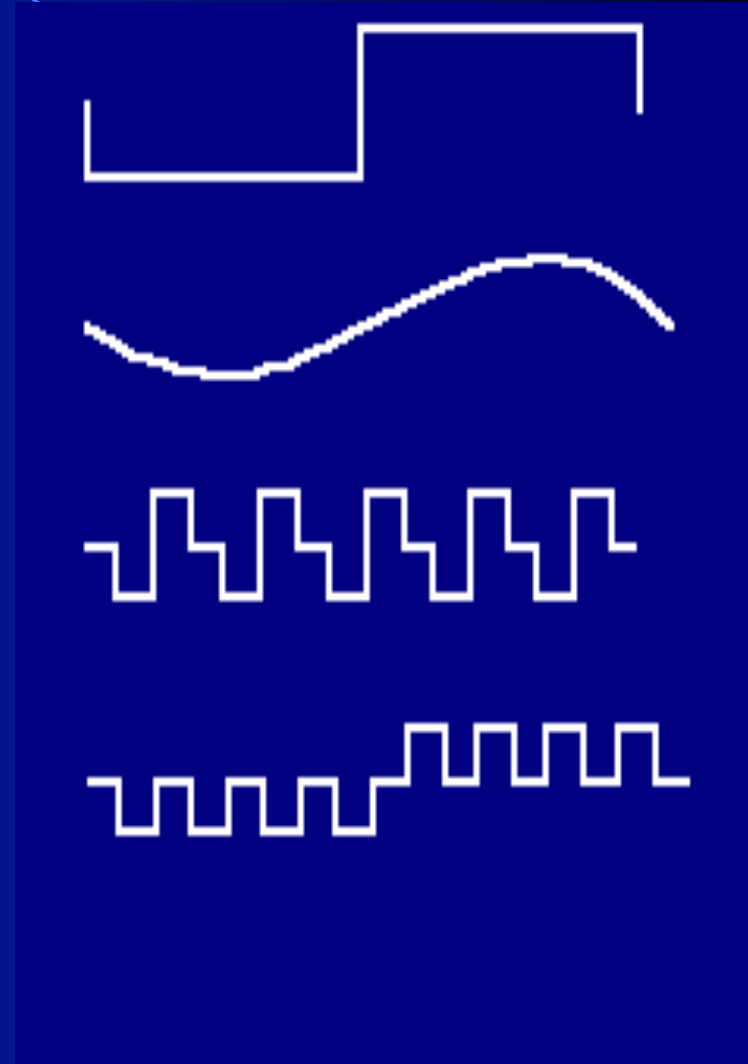


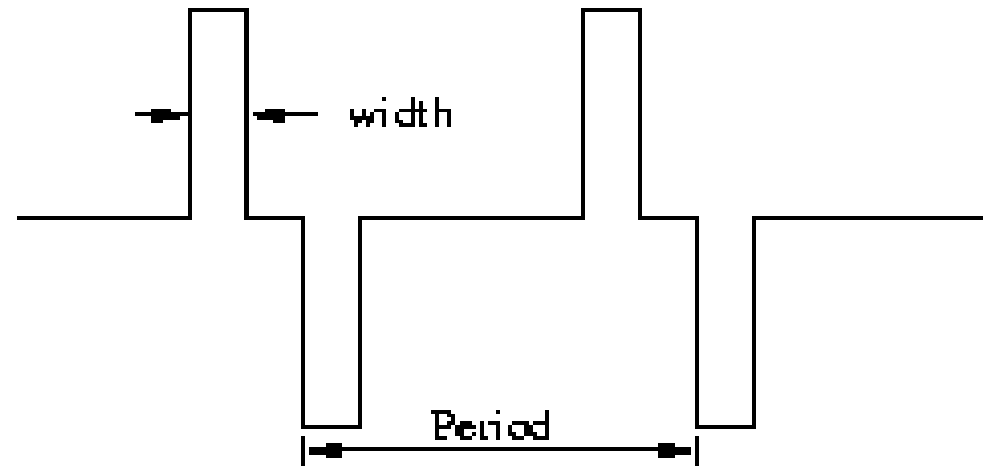
# Electric Stimulation Parameters For Intracortical Recording of Normal and RD Mice

- Square wave.
- Sine Wave.
- Monophasic pulse train.
- Biphasic pulse train.



# Electrical Pulse Specification

- Width - (0.1 ms, 2 ms)
- Period - (10 Hz, 125 Hz)
- Magnitude - (10  $\mu\text{A}$ , 600  $\mu\text{A}$ )

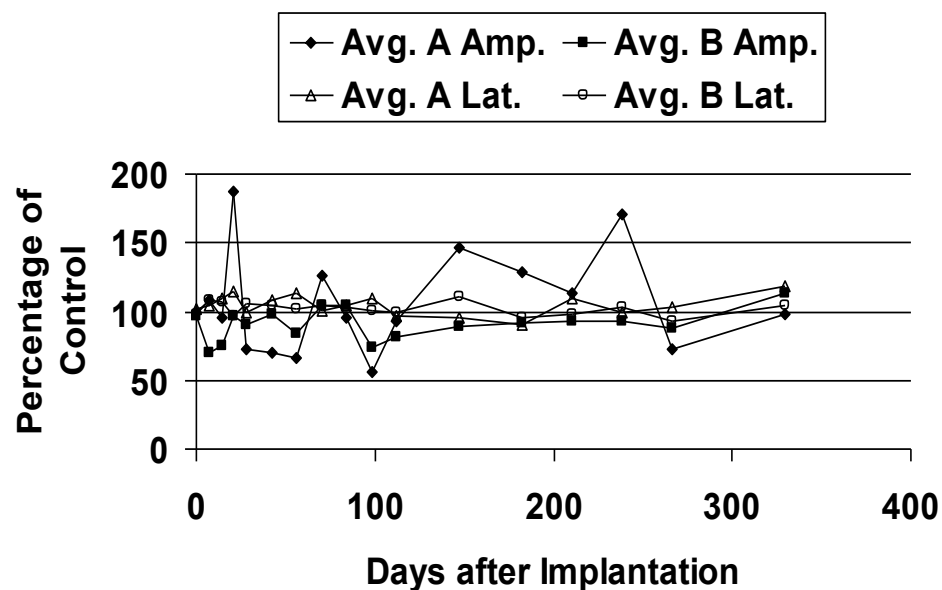
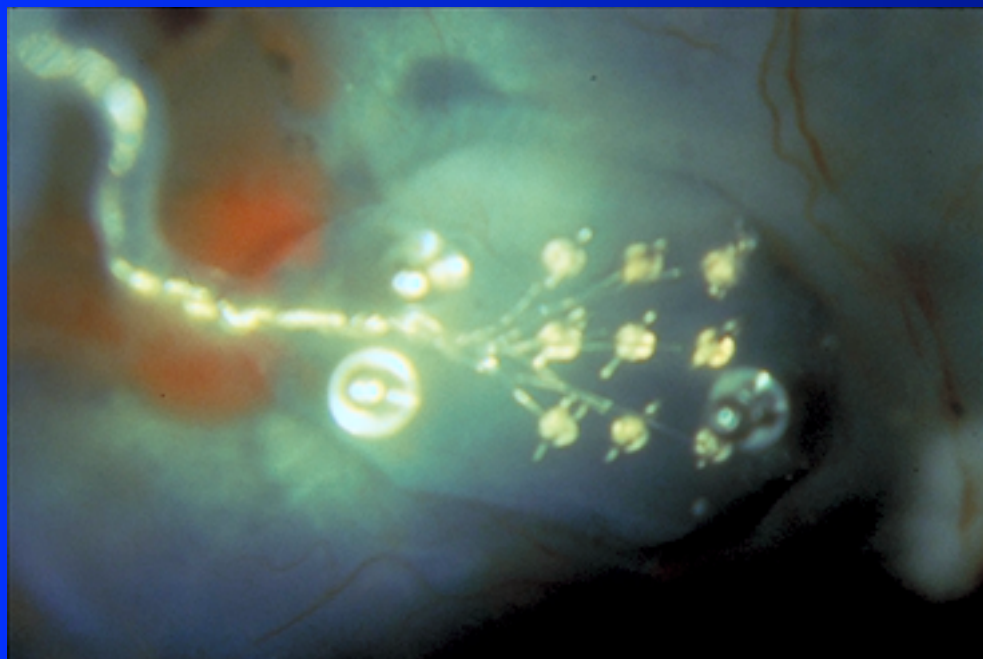


# Developing an Implantable Prosthesis

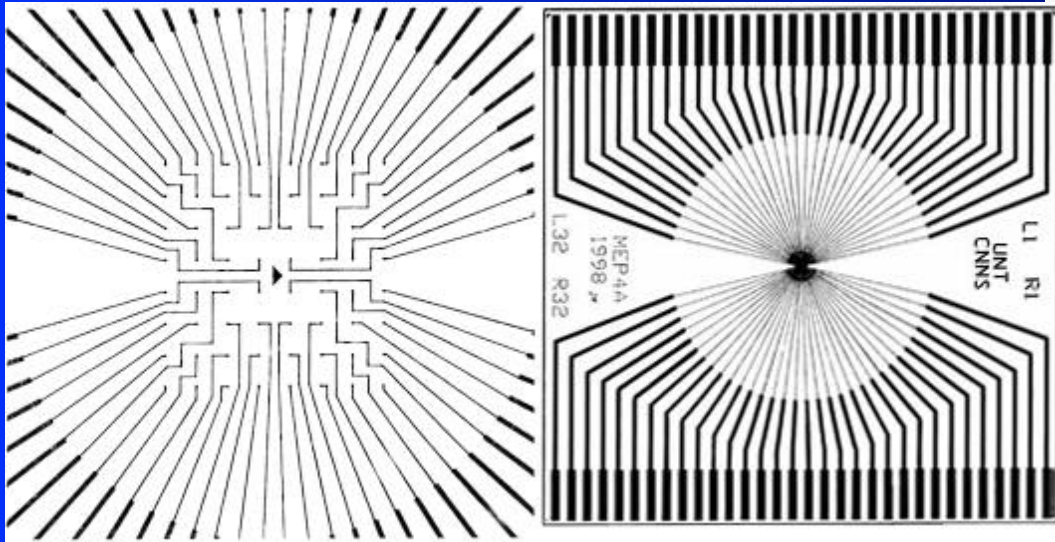
- Anatomy of the visual system in normal and RP individuals.
- Concept of the retinal prosthesis.
- Understanding how electric current drives the retina in blind RP and AMD individuals.
- Prosthesis technology development.
- Assess the efficacy and safety of the prosthetic device in animals.
- Human experiments.

# Long-term Insertion of Inactive Devices in Dogs

## In-Vivo Experiments



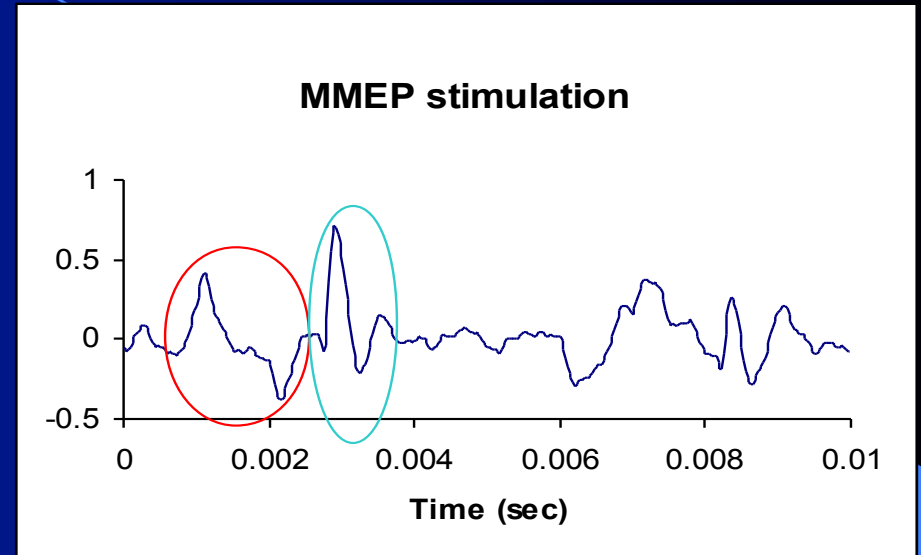
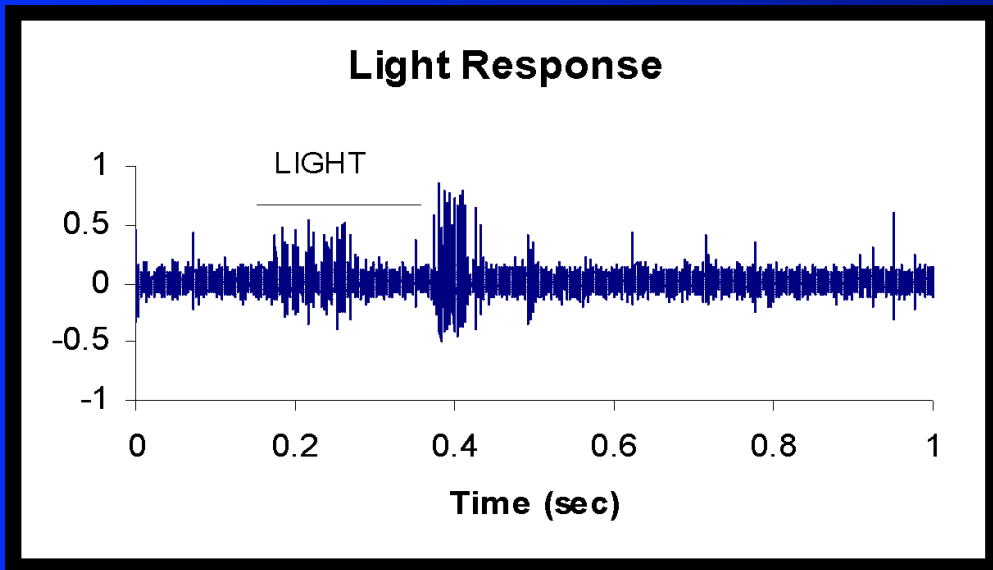
# Chamber Used in Isolated Retina Experiments



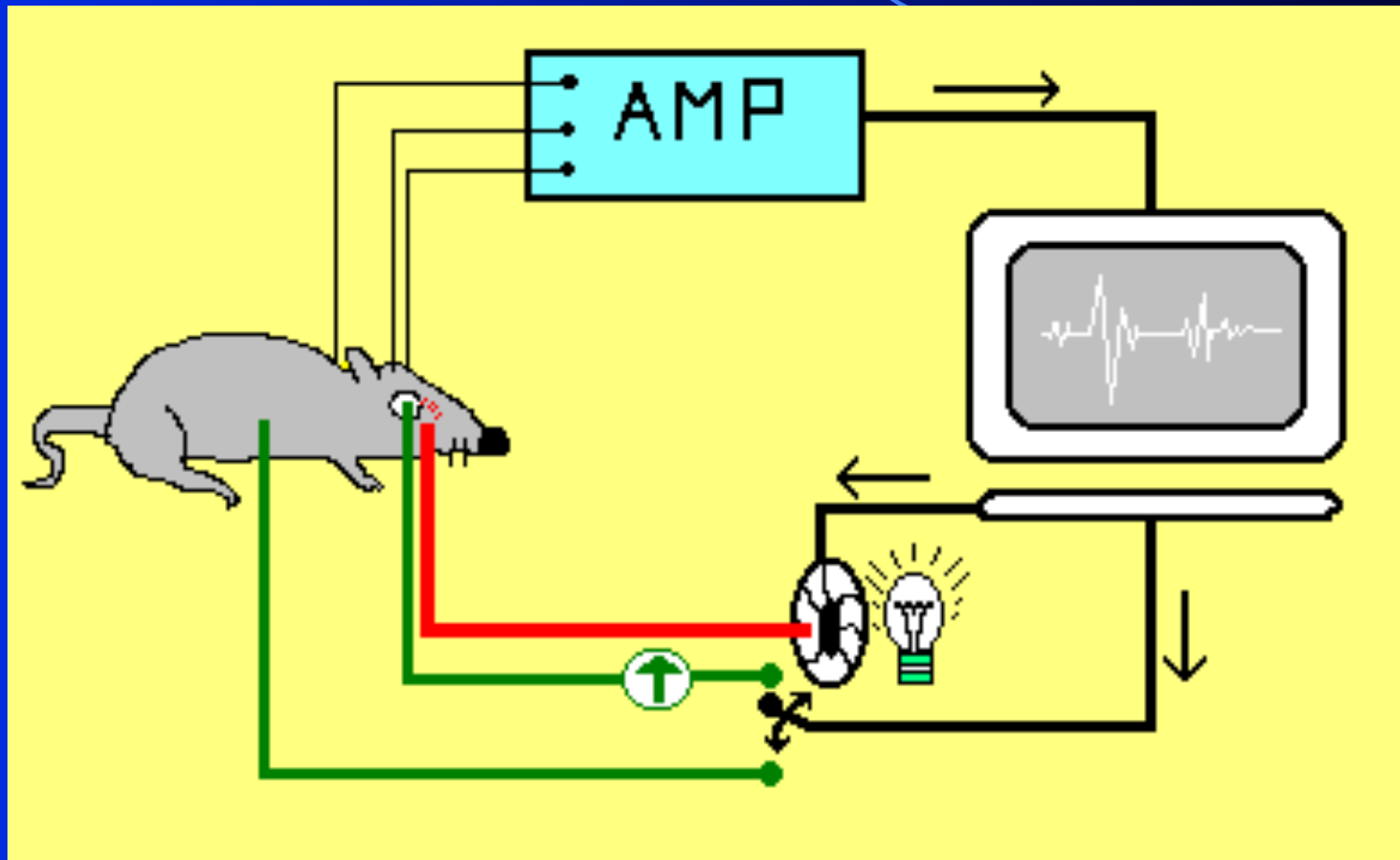
*Shyu et al, 2006*



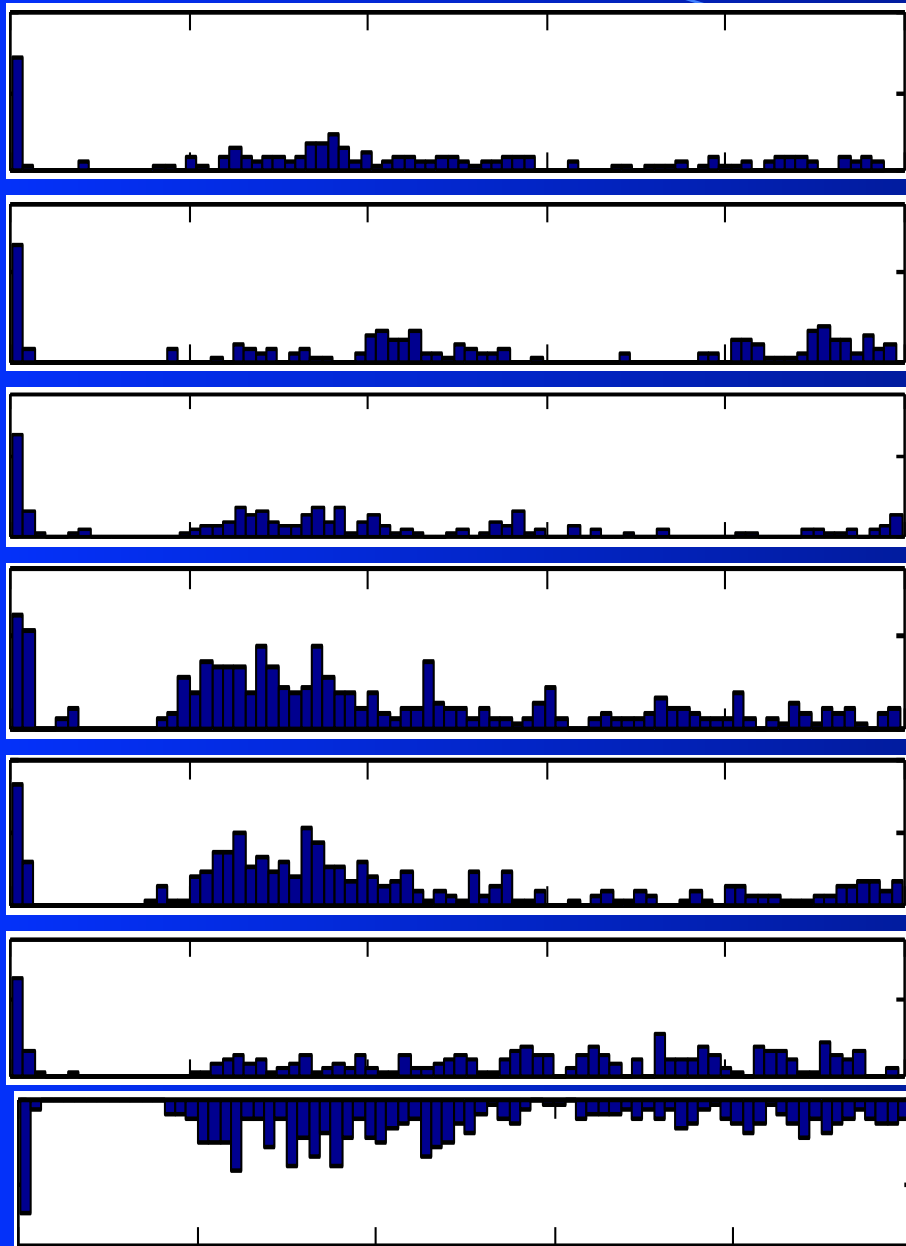
# Light and Electrical Response in Isolated Retina Experiments



# Stimulation & Recording Setup for Intracortical Recording of Normal and RD Mice



# Electrical Response from Intracortical Recording of Normal Mice



400u

450u

500u

550u

600u

650u

700u

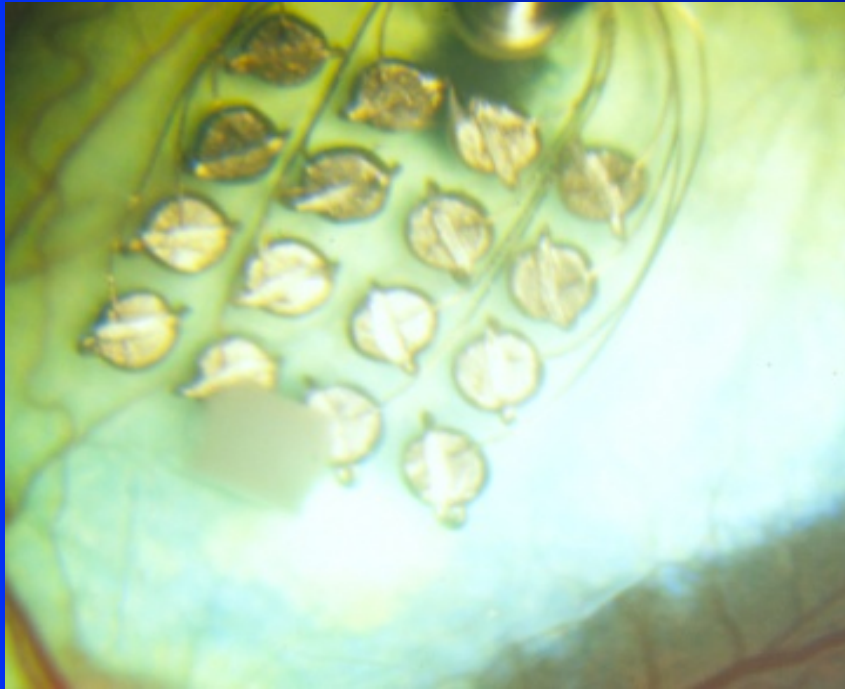
20 No.

200 ms

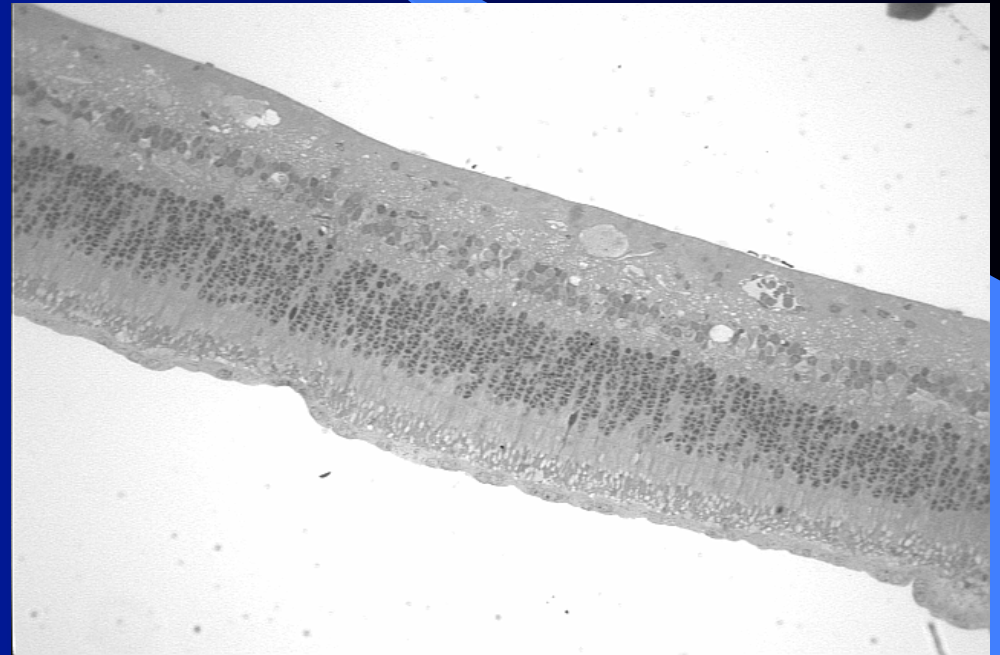




# Chronic Stimulation

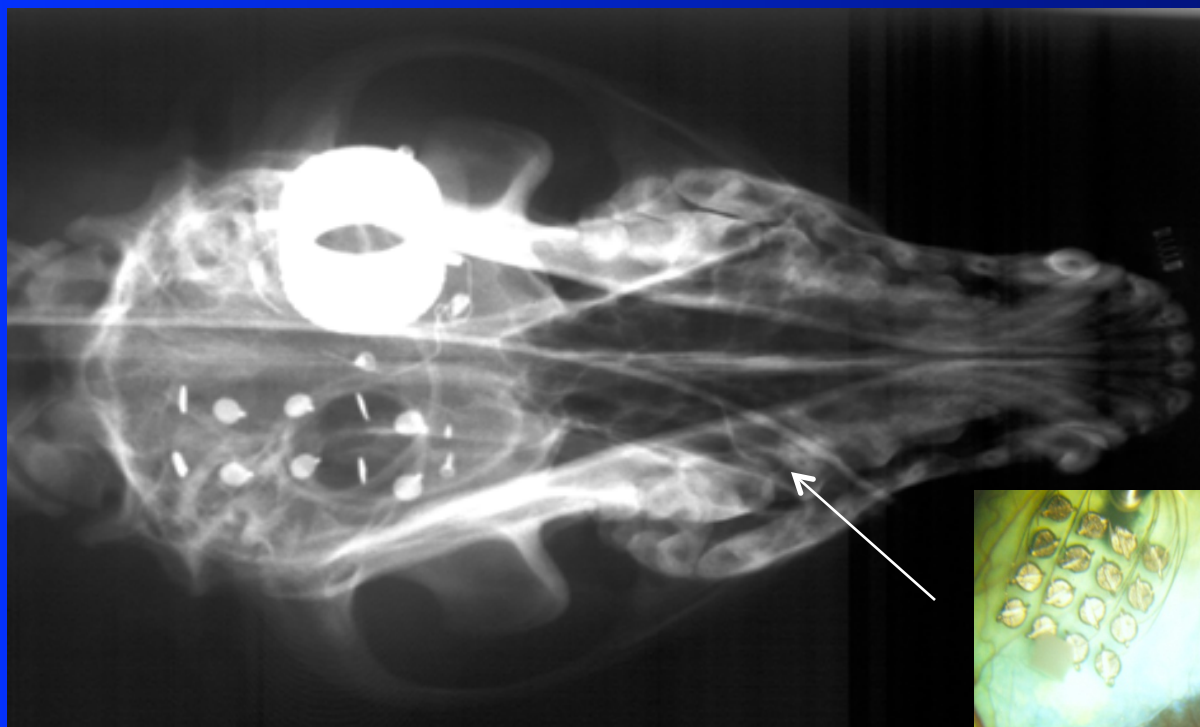
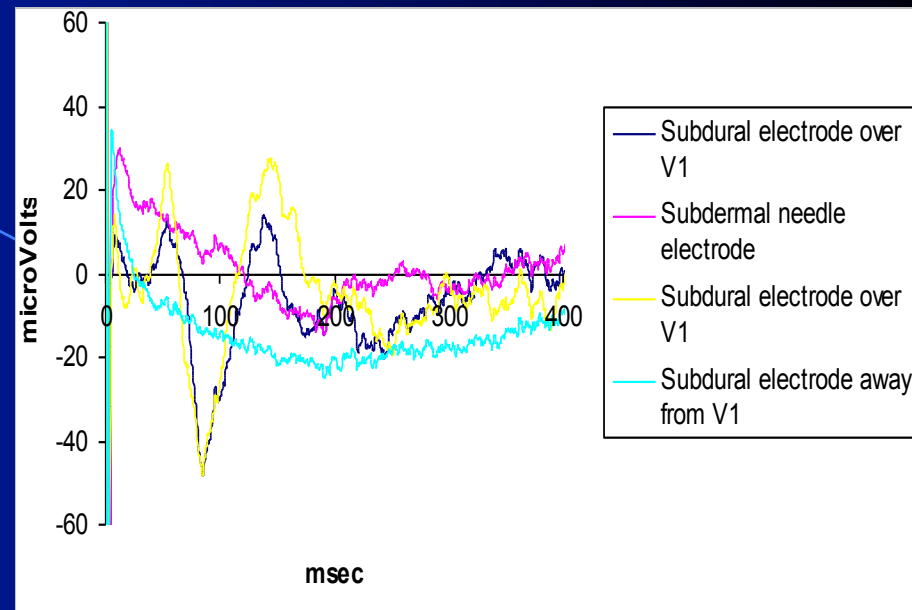


Histology shown from retina under electrode array after 25 days of stimulation over 2 months of implantation.



*Weiland et al, 2005*

# What does the dog see during electrical stimulation?



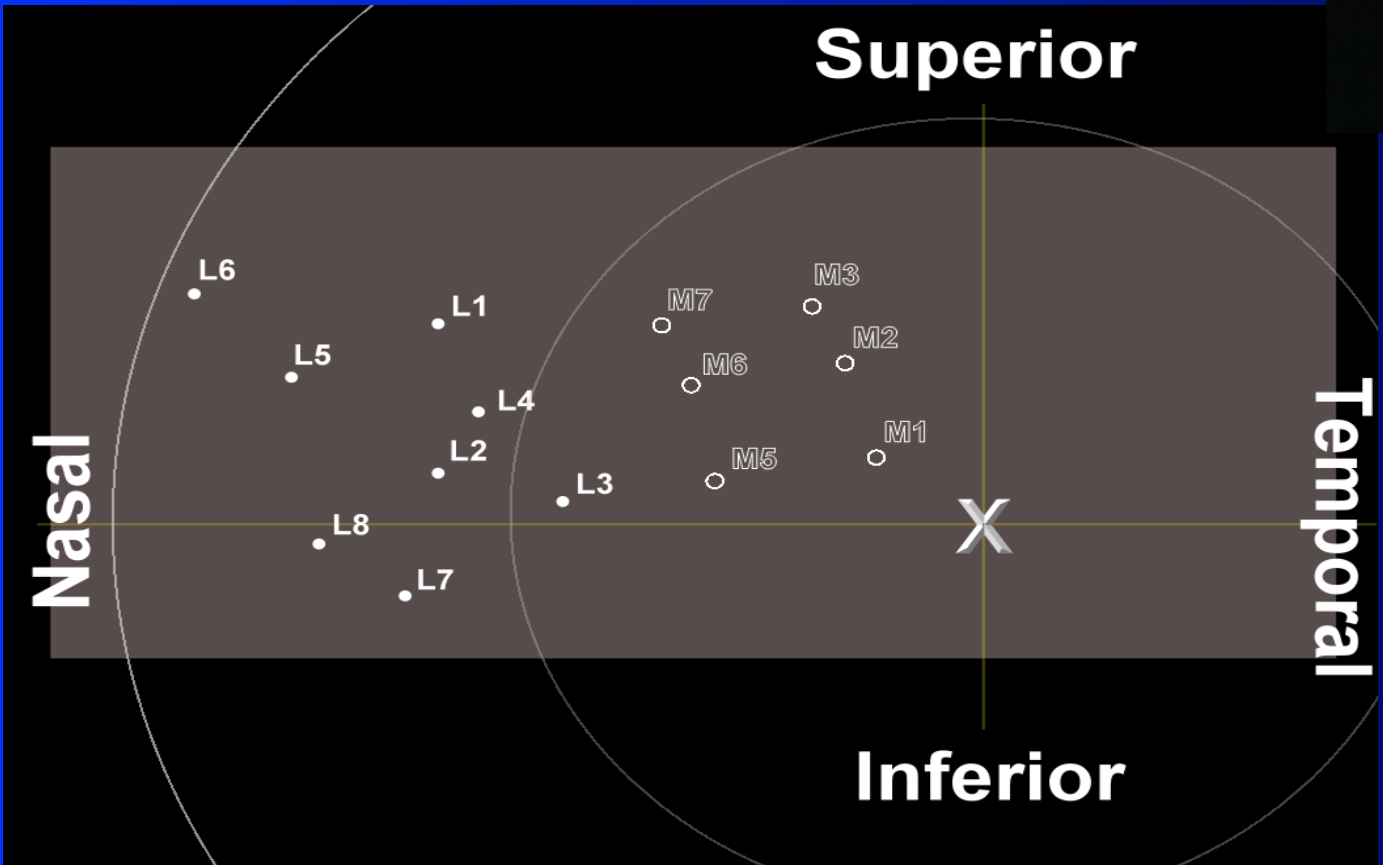
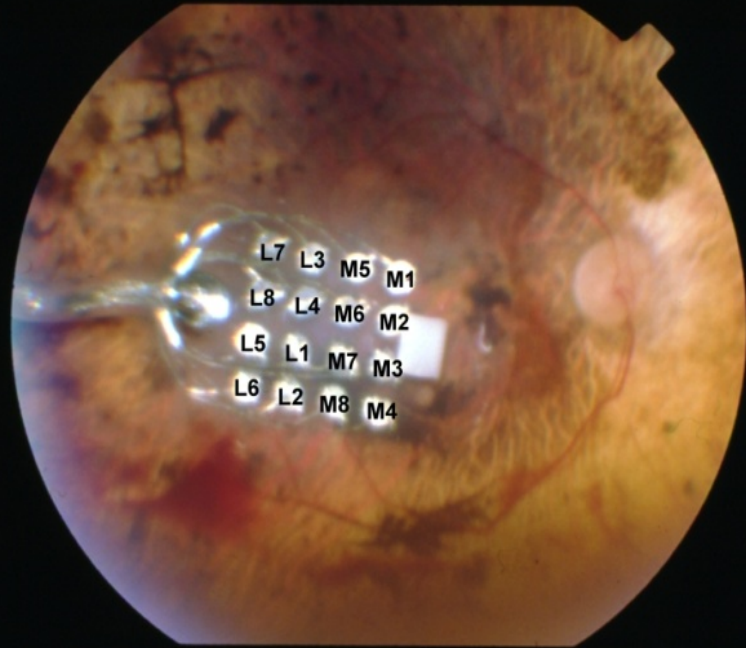
## Conclusions

- Chronic electrical stimulation of the retina did not result in visible damage to the retina (in agreement with histology).
- Cortical responses obtained to multi-channel stimulation.
- Surgical approach of the epiretinal prosthesis continues to be refined.

# Developing an Implantable Prosthesis

- Anatomy of the visual system in normal and RP individuals.
- Concept of the retinal prosthesis.
- Understanding how electric current drives the retina in blind RP and AMD individuals.
- Prosthesis technology development.
- Assess the efficacy and safety of the prosthetic device in animals.
- Human experiments.

In 2012 the European Union approved Second Sight's device for marketing and the FDA recommended approval based on clinical trials, which were performed in both continents.



# Project Team Members

## Acknowledgments

### Johns Hopkins University

- *Mark Humayun*
- *Eugene de Juan Jr.*
- *James Weiland*
- *Shih-Jen Chen*
- *Jeng-Shyong Shyu.*
- *Eyal Margalit*
- *Duke Piyathaisere*
- *Salvatore D'Anna*
- *Rhonda Grebe*
- *Gislin Dagnelie*
- *Gildo Fujii*
- *Mauricio Maia*
- *Gustavo Torres*
- *Terry Shelley*

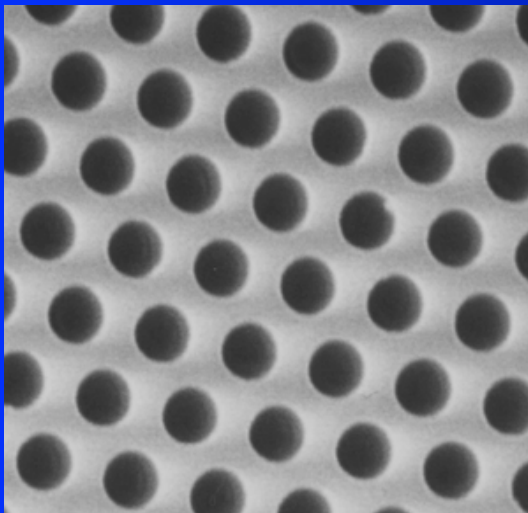
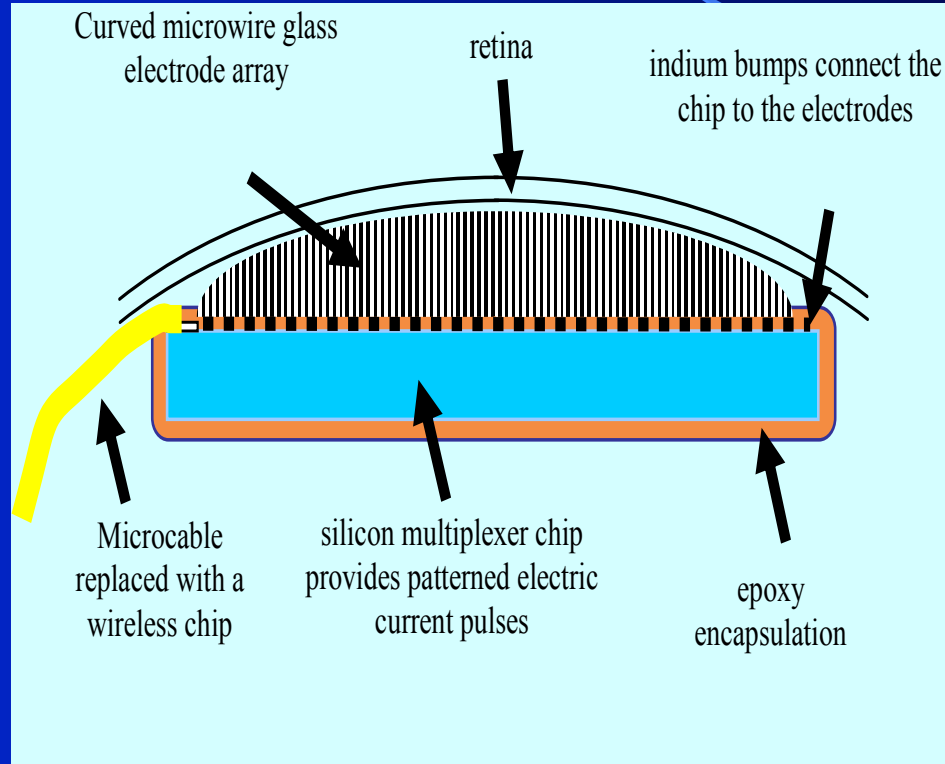
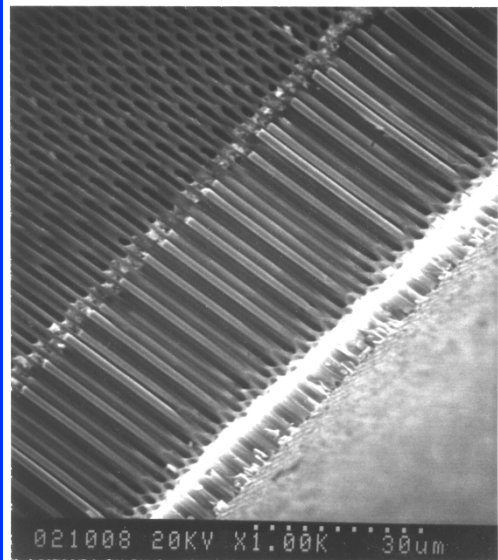
### Outside Collaborators

- *Robert Greenberg (Second Sight)*
- *Dean Scribner (Naval Research Lab)*
- *Wentai Liu (U. North Carolina)*
- *Texas Instruments*
- *IBM*

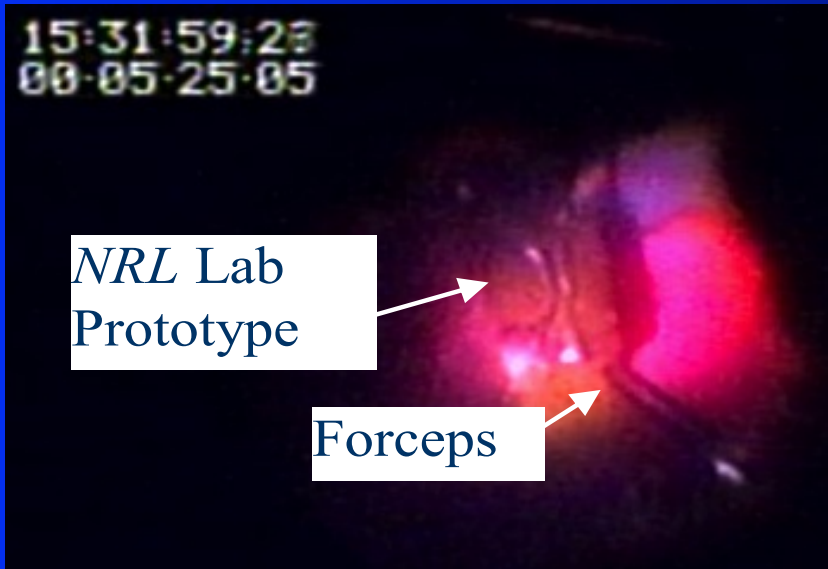




# The Nebraska Retinal Prosthesis Project

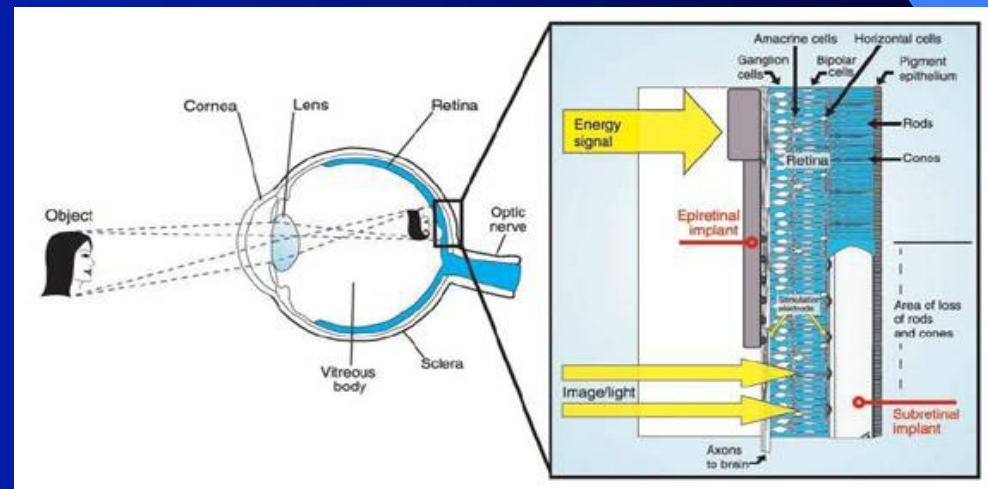
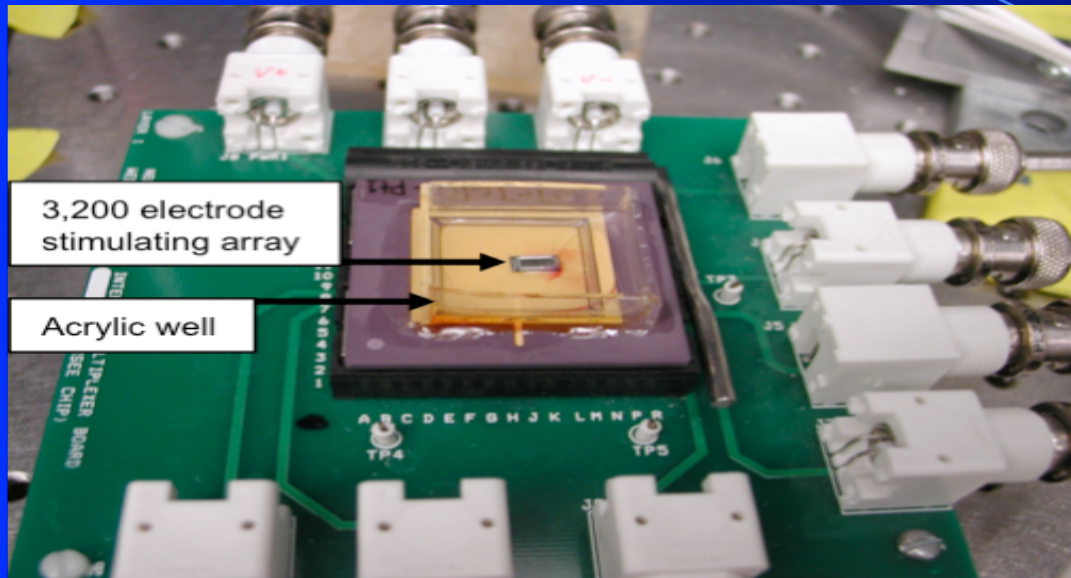


# In-Vivo Experiments



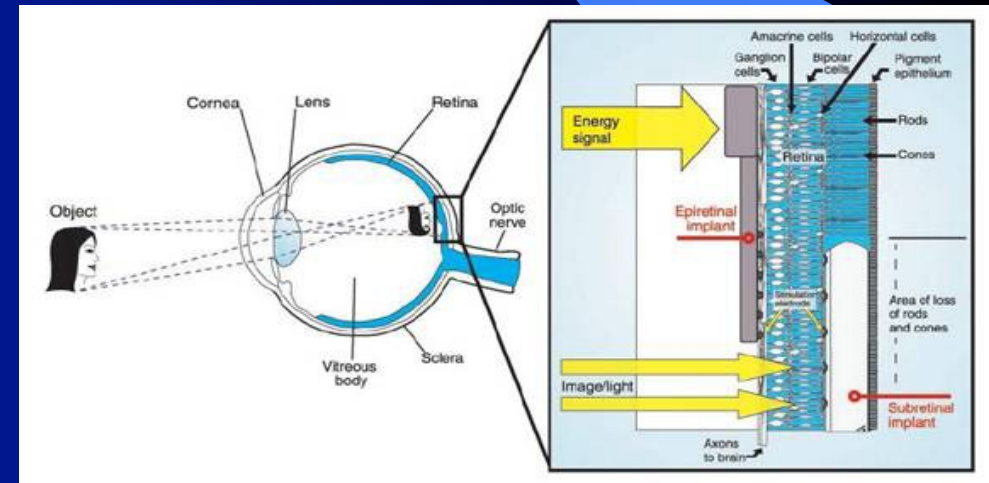
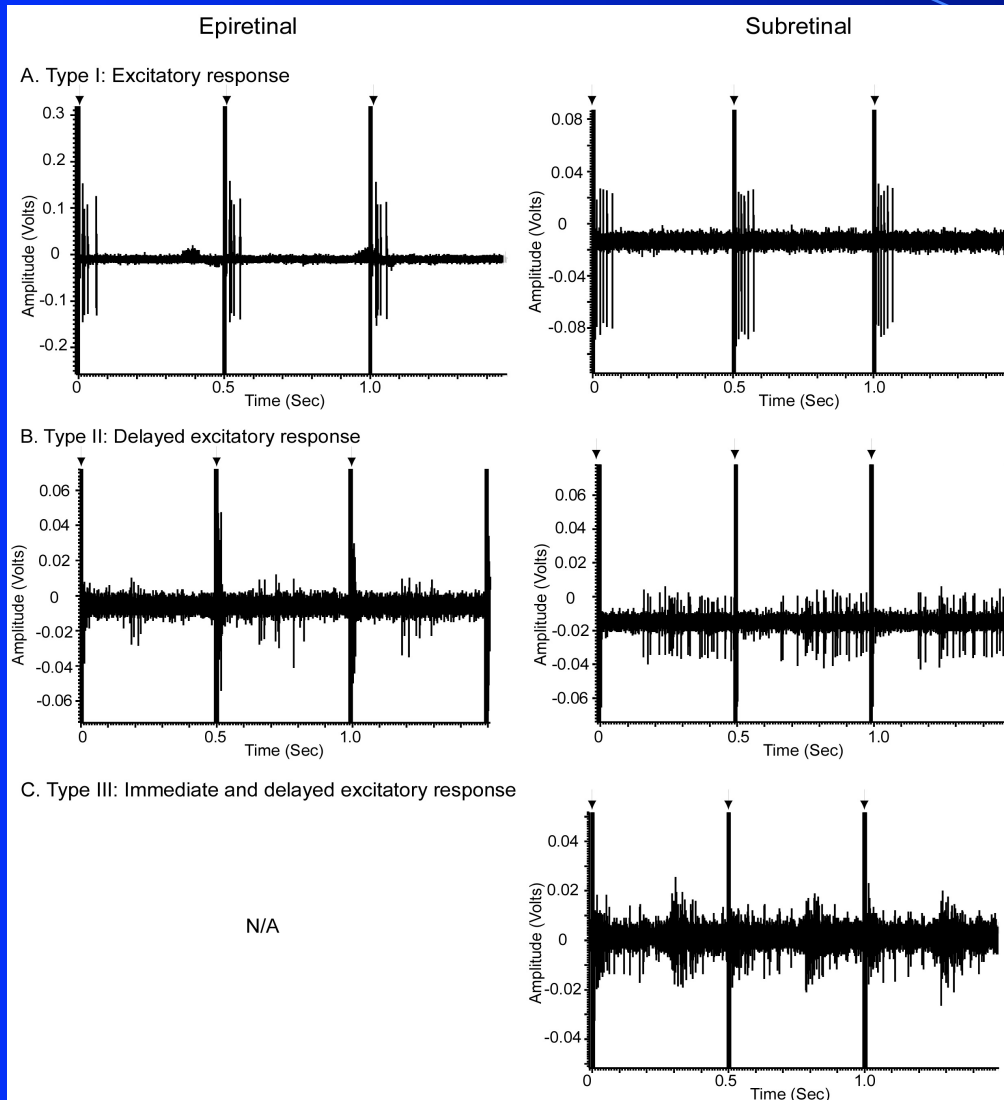


# Electrophysiological experiments

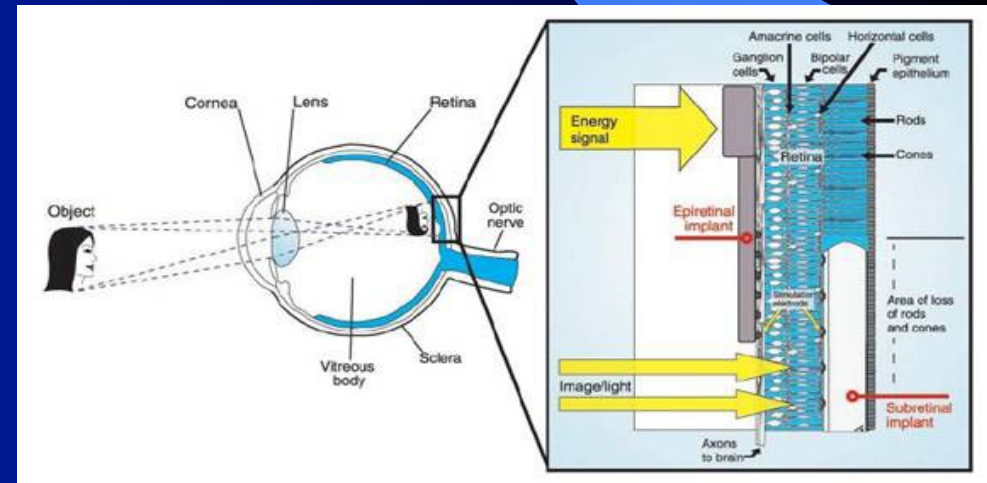
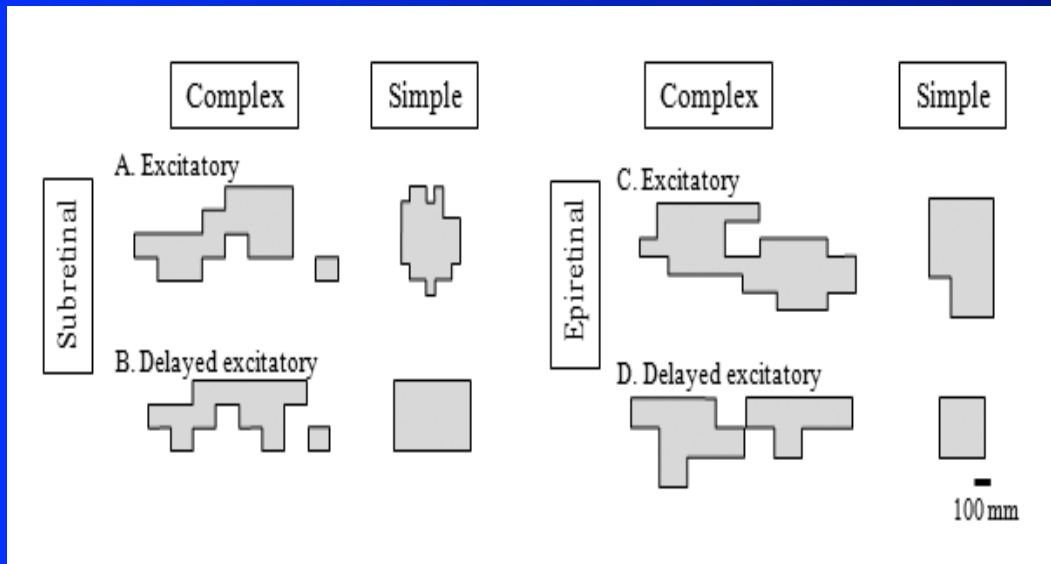


*Margalit, Thoreson et al, 2006, 2011, 2012*

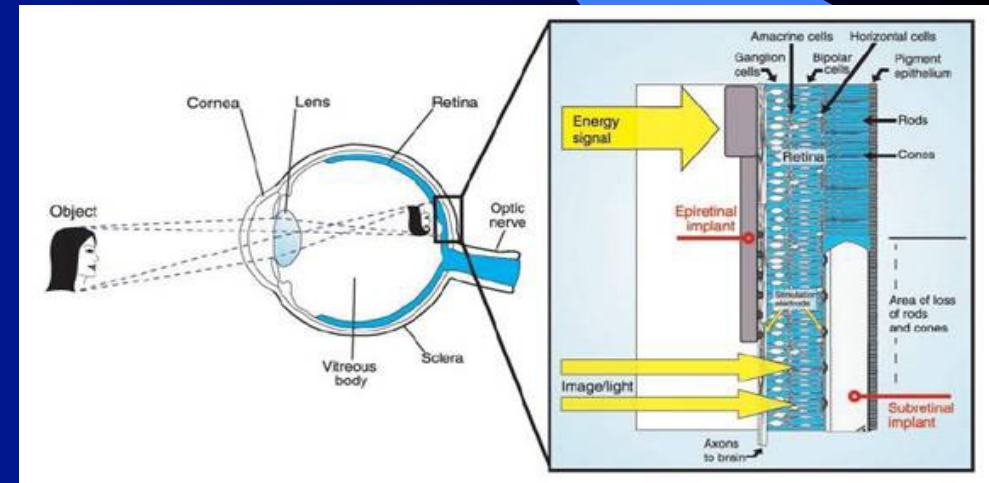
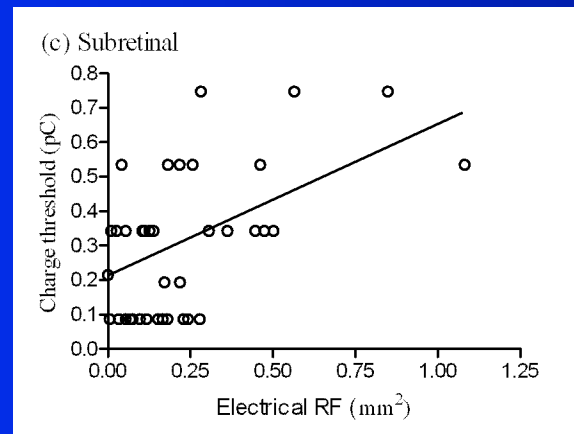
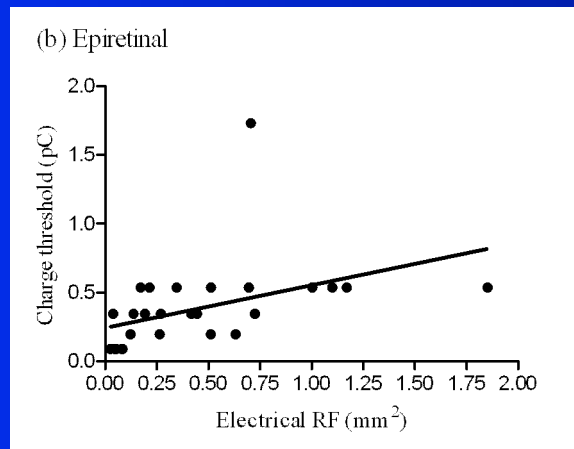
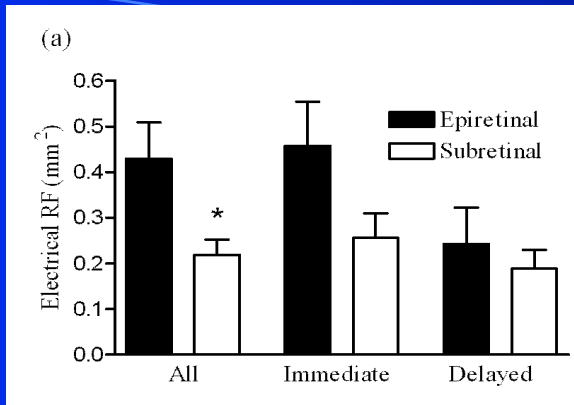
# Electrophysiological experiments



# Electrophysiological experiments



# Electrophysiological experiments



# Project Team Members

## Acknowledgments

### University Of Nebraska

- *Wallace Thoreson PhD*
- *Sylvie Sim*
- *Robert Szalewski*
- *Norbert Babai PhD*
- *Jianmin Luo PhD*
- *Paul Hruby MD*
- *Hesham Ali PhD, College of computer Sciences- Dean*

### Outside Collaborators and funding

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**Thank You!**

