Retinal Remodeling

CS 790R Project Proposal

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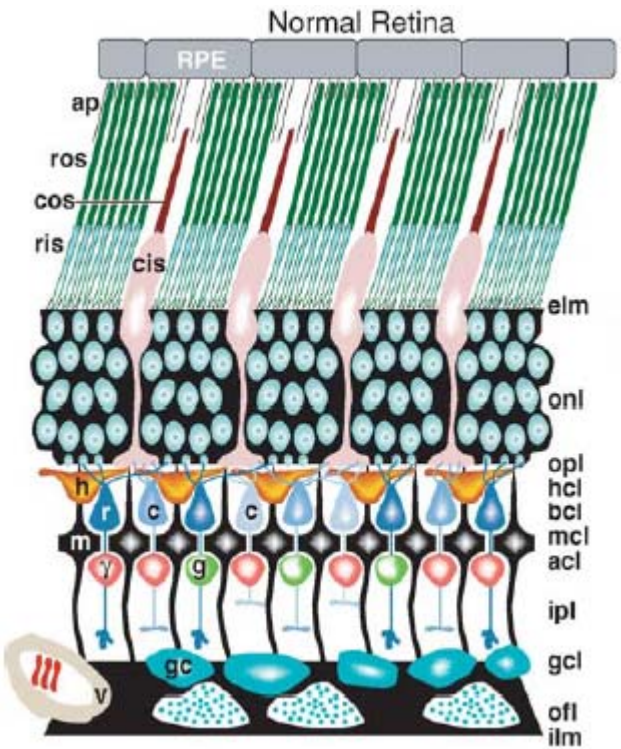
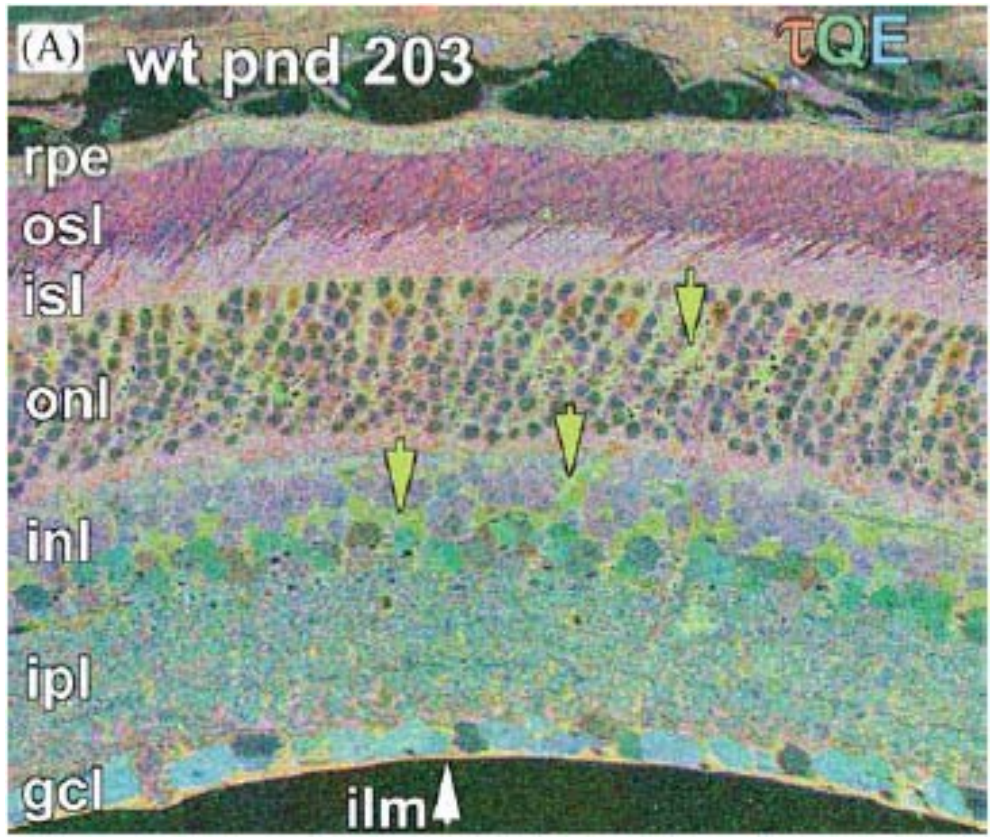
Outline

- The system
  - Retinal degeneration and blindness
  - Retinal remodeling interfering with recovery
- The proposed models
  - Feed-forward neural network
  - Multiple ant colonies
- Methodology
- Implementation

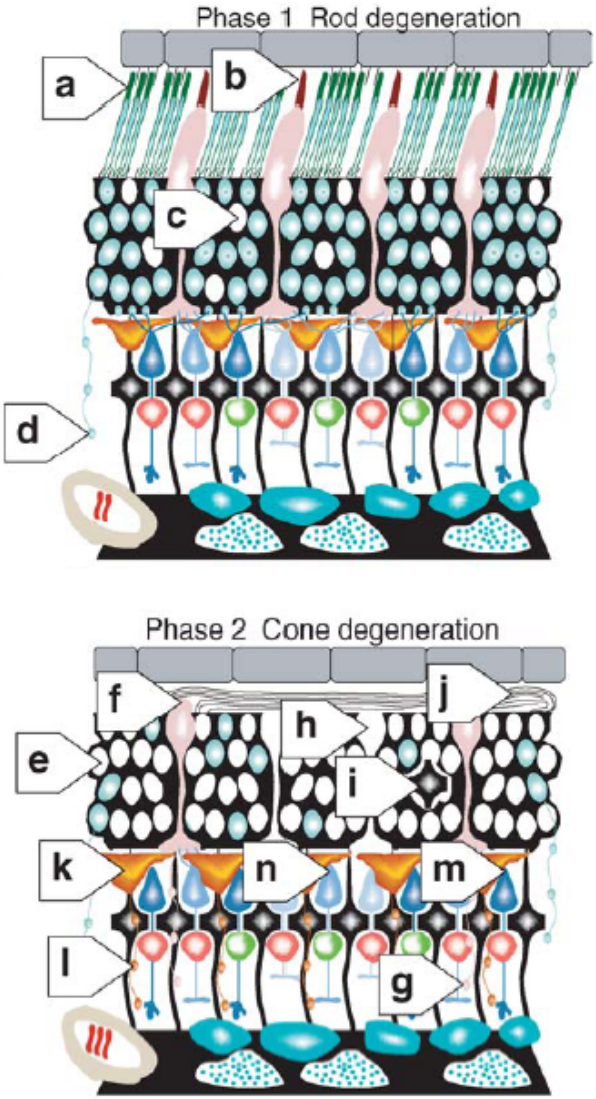
Retina – Layered Neural Network



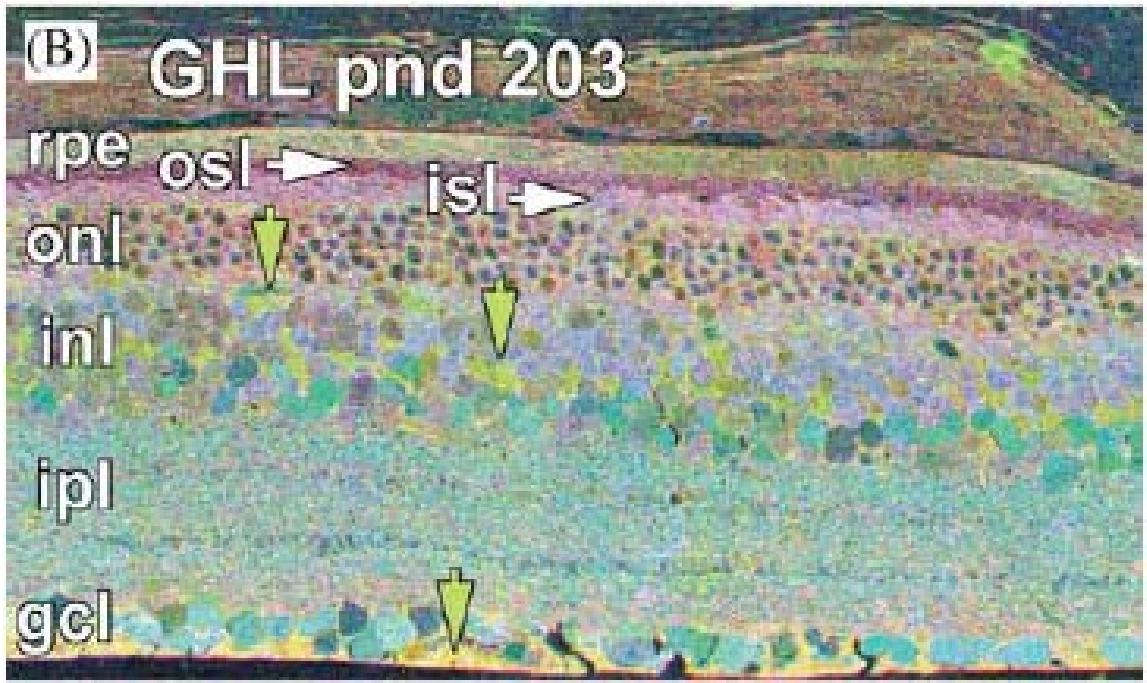


Marc R. E., Jones B. W., Watt C. B., and Strettoi E. (2003)
Neural remodeling in retinal degeneration. *Progress in Retinal and Eye Research* **22**: 607–655

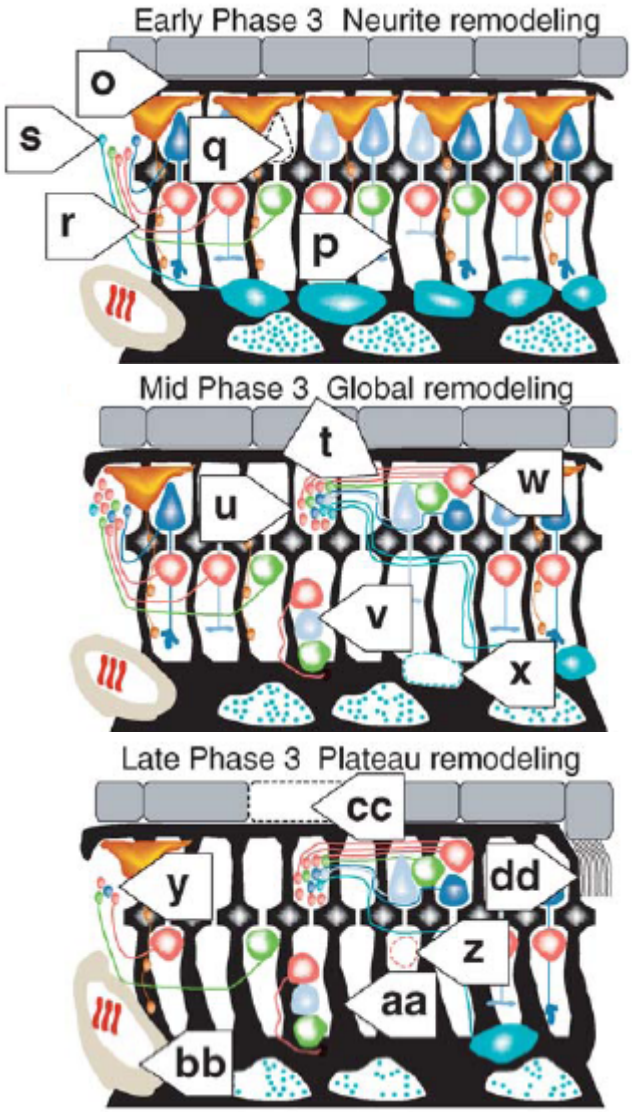
Retina – Receptor Death



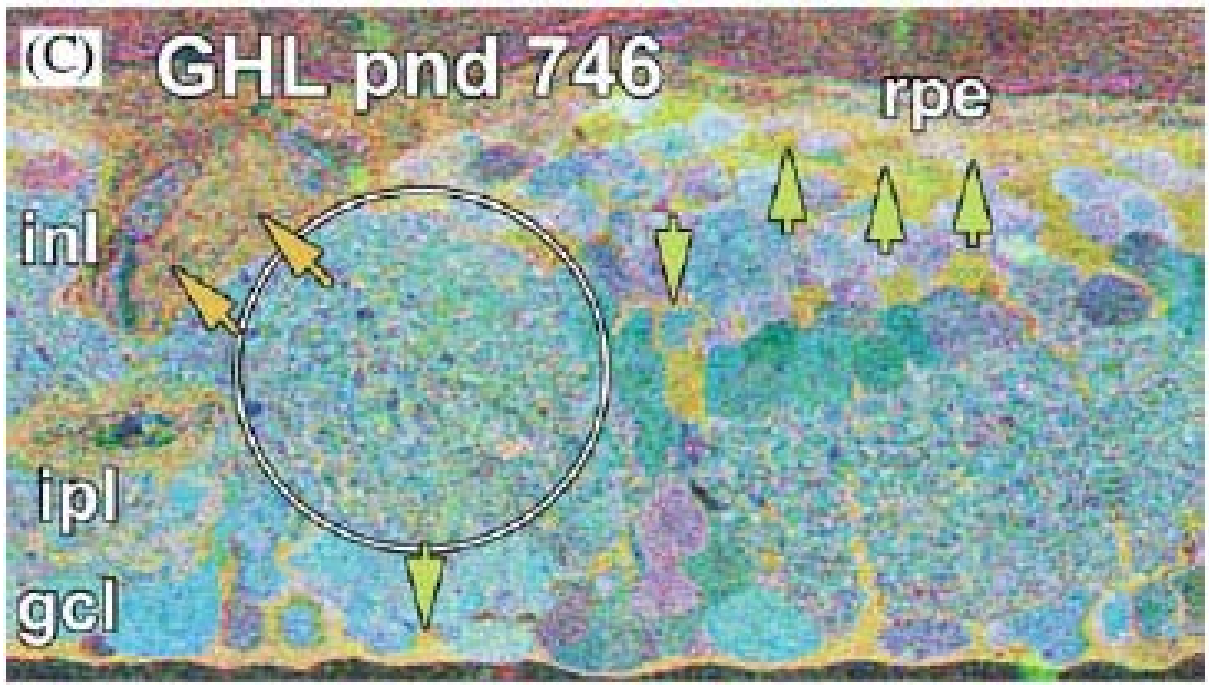
- Rods & cones die
- Sensory & neural (soma's) layers collapse



Retina – Remodeling



- Surviving cells send out new processes
- Cells migrate to other areas



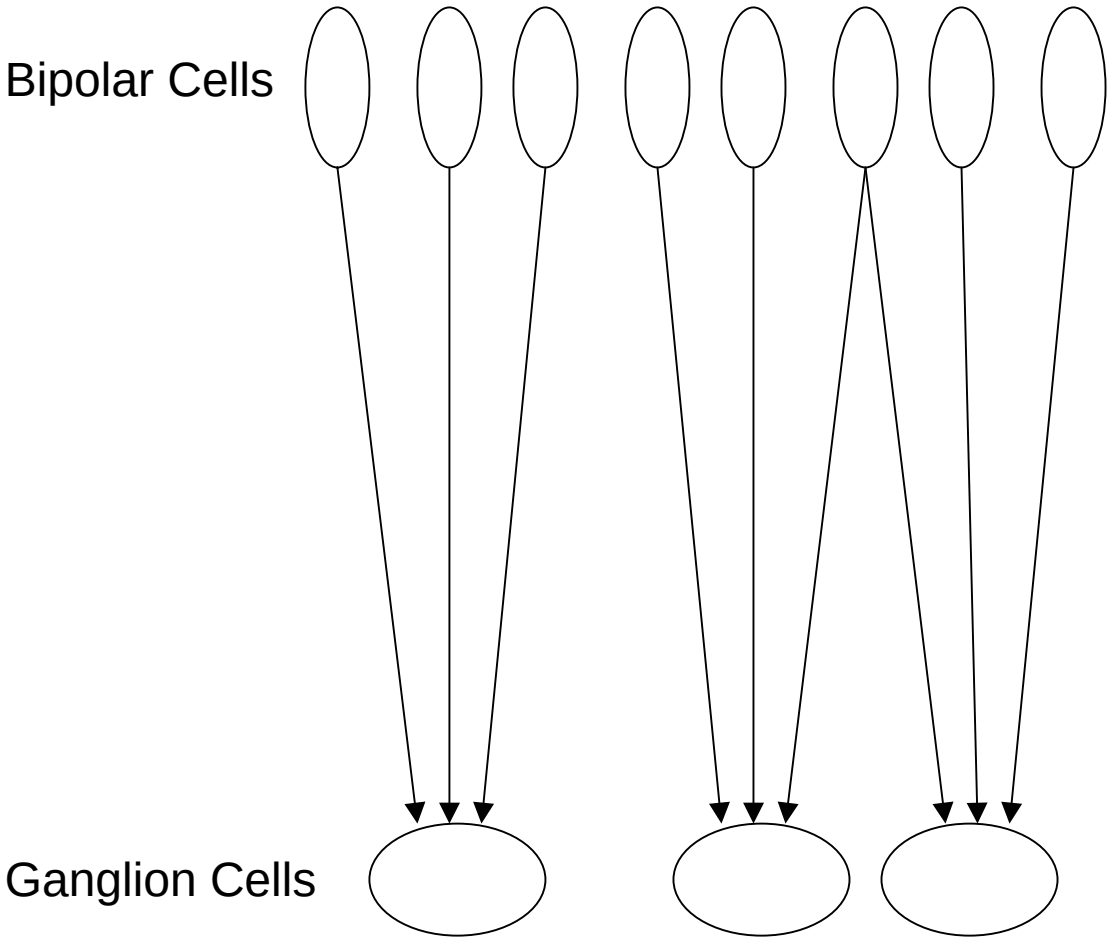
Proposed Model

- Create a layered network to mimic the functioning neural retina
- Use ant foraging model to simulate neurites searching for new input
- Retest remodeled network and compare the output

Proposed Model – Neural Network

- Create a layered network to mimic the functioning neural retina
  - Bipolar and ganglion cell layers operate as feed forward network
  - Horizontal and amacrine cell layers operate as localized attractor network
  - Network will be trained with different objects and/or patterns

Proposed Model – Neural Network

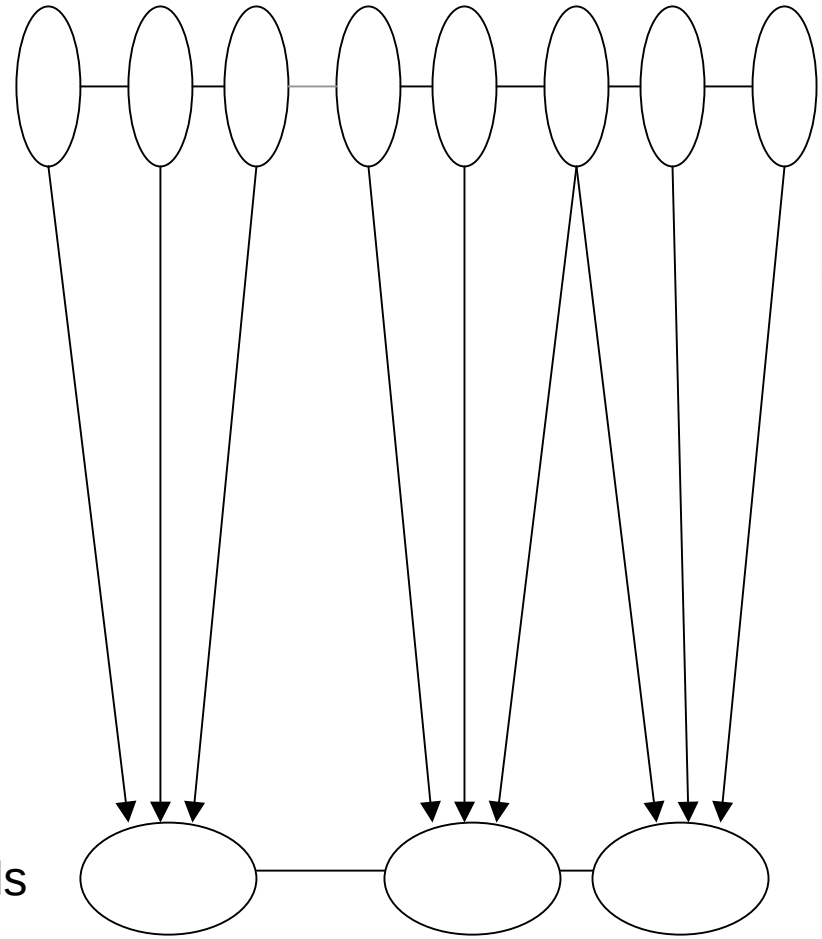


Simplest model

Feed forward network:
Bipolar Cells = Input Layer
Ganglion Cells = Output Layer
Ganglion cell input comes from multiple bipolars

Proposed Model – Neural Network

Bipolar Cells

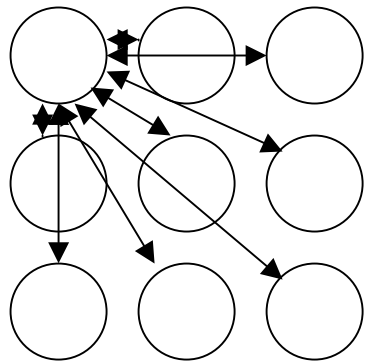


Ganglion Cells

Added complexity

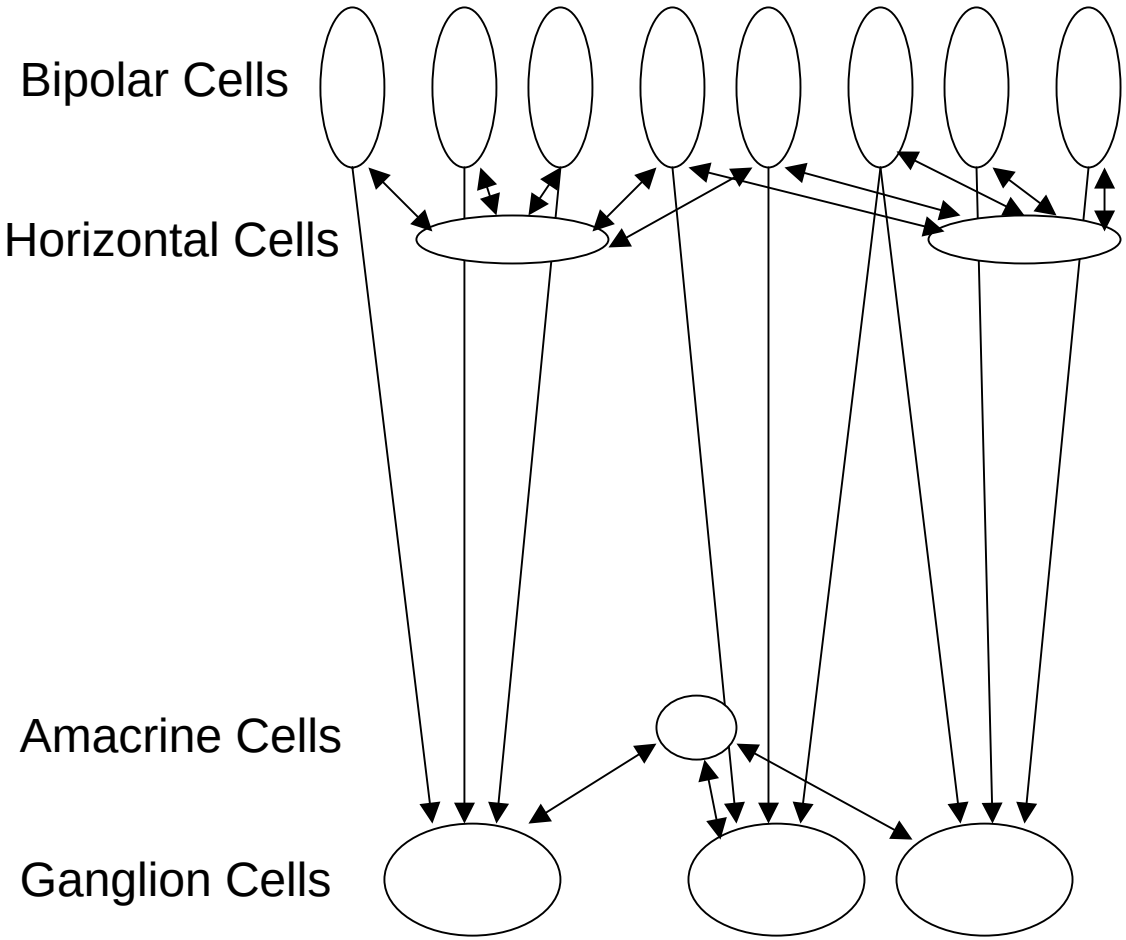
Cells within each layer are interconnected to each other

Repeat for each cell



Top View

Proposed Model – Neural Network

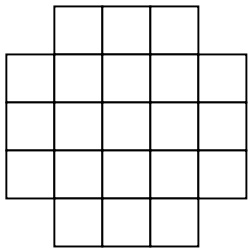
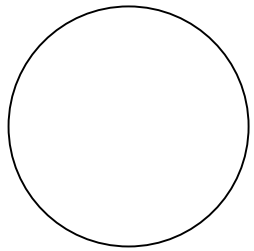
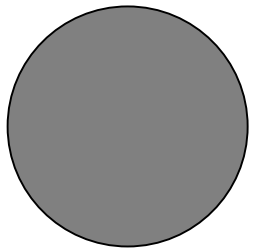
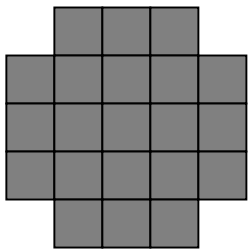
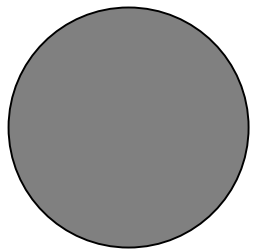
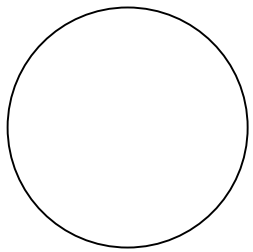
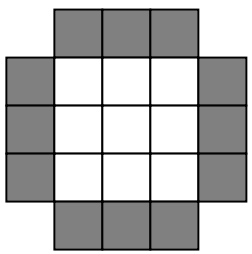
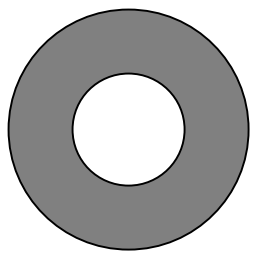
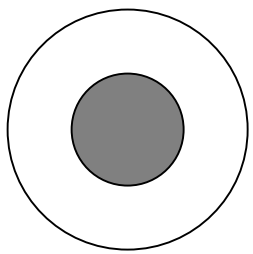


More complexity

Introduce horizontal and amacrine cells for interconnection within layers

Ultimate goal is to simulate receptive fields of the ganglion cells

Proposed Model – Neural Network

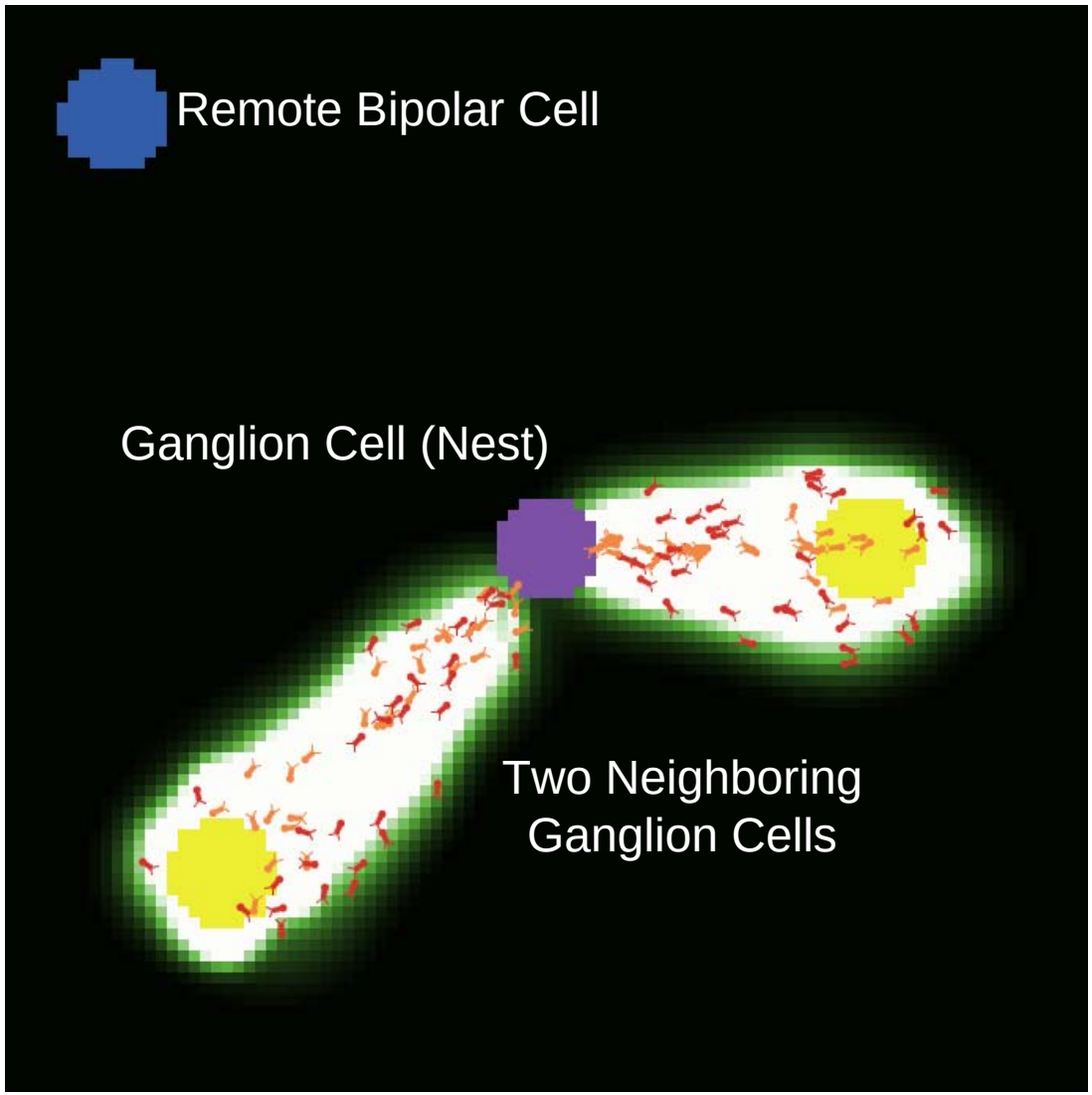
Bipolar Input	Ganglion Cell Behavior	Cell A	Cell B
	On Cell (A) would produce more spikes Off Cell (B) would produce fewer spikes		
	On Cell (A) would produce fewer spikes Off Cell (B) would produce more spikes		
	On center off surround cell (A) would produce more spikes Off center on surround cell (B) would produce fewer spikes		

Add only enough complexity to the neural network layout necessary to create these kinds of receptive fields

Proposed Model – Ant Colonies

- Use ant foraging model to simulate neurites searching for new input
  - Each neuron becomes a nest
  - Ant foragers look for food sources (other neurons of the appropriate type)
  - If a nest can’t bring in food at a minimum rate it will die
  - Ultimately new neuron connections established as the strength of ant trails

Proposed Model – Ant Colonies



- Cells and their established connections decay over time
- New strength is added to connections based on strength of ant trail
- Food at each source (other neurons) does not reduce with consumption by ants but by the decay of the cell
- Cells can remain alive by establishing an equilibrium with each other

Proposed Model – Lost "Potential" Vision

- Retest remodeled network and compare the output
  - Use the same test inputs and observe the outputs
  - Quantify the variation in the outputs
  - Use those numbers to determine time course of the model
  - Adjust parameters to more accurately match the real thing

Implementation

- Randomly position neurons for each layer aiming for specific spatial density
- Establish connections based on rules from the natural system and training
- Run ant colony simulation with each neuron acting independently
- Compare network output after remodeling
- Tweak parameters

Implementation

- Language: Visual Basic
  - Existing modules to make things easier – unknown
  - Possibly utilize NetLogo or some other utility for one model and/or the other
- Graphics: Simplistic 2D representations of the actual network
  - Excel: plotting of data
- Input/Output images

Questions?