

# Topographic map formation

Lecture 1 of 2

Stephen J Eglen

University of Cambridge

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## Background

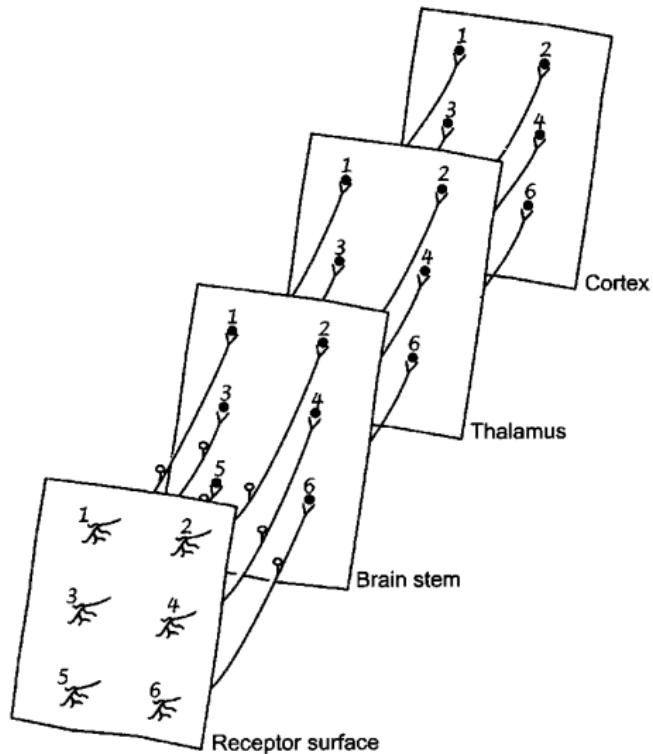
## Reading list

Key papers online at:

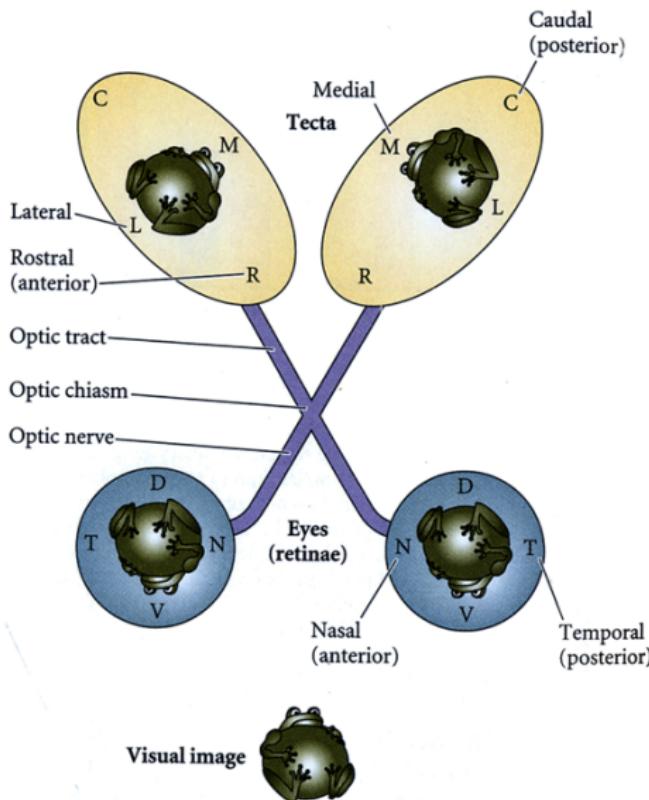
[http://www.damtp.cam.ac.uk/user/sje30/teaching/nst\\_neuro](http://www.damtp.cam.ac.uk/user/sje30/teaching/nst_neuro)

## Introduction to maps

# What is a map?



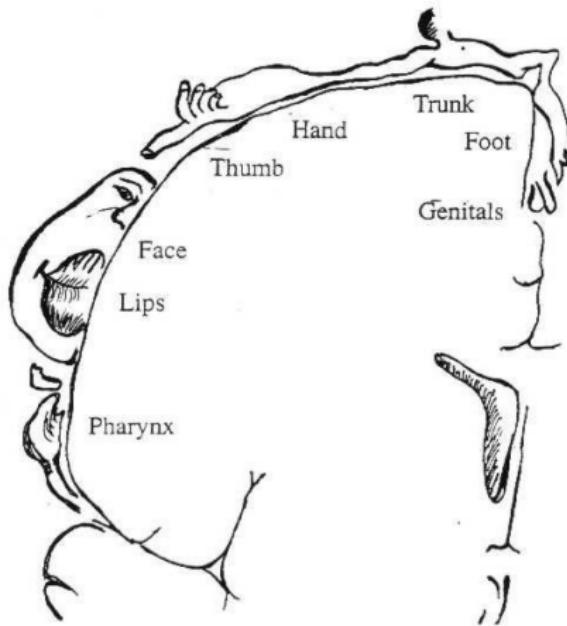
# Sperry



## Topographic connections

- Neighbouring cells in the retina terminate next to each other in the target (tectum).
- A map of visual space is preserved in the brain.

# Somatosensory maps



<http://faculty.washington.edu/chudler/flash/hom.html>

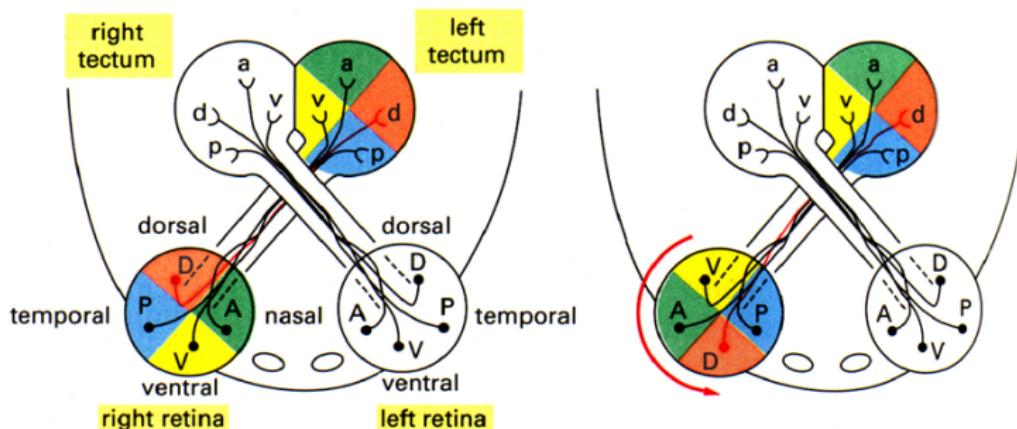
## Map plasticity

- How do maps wire up?
- How do they recover after injury?

## Sperry's experiments:

- 1) Rotation of the eyes of a newt or frog by 180°.
- 2) Cutting of the optic nerves prior to rotation of the eyes by 180°.

In both experiments the animals see their world upside down and back to front. This condition is irreversible.



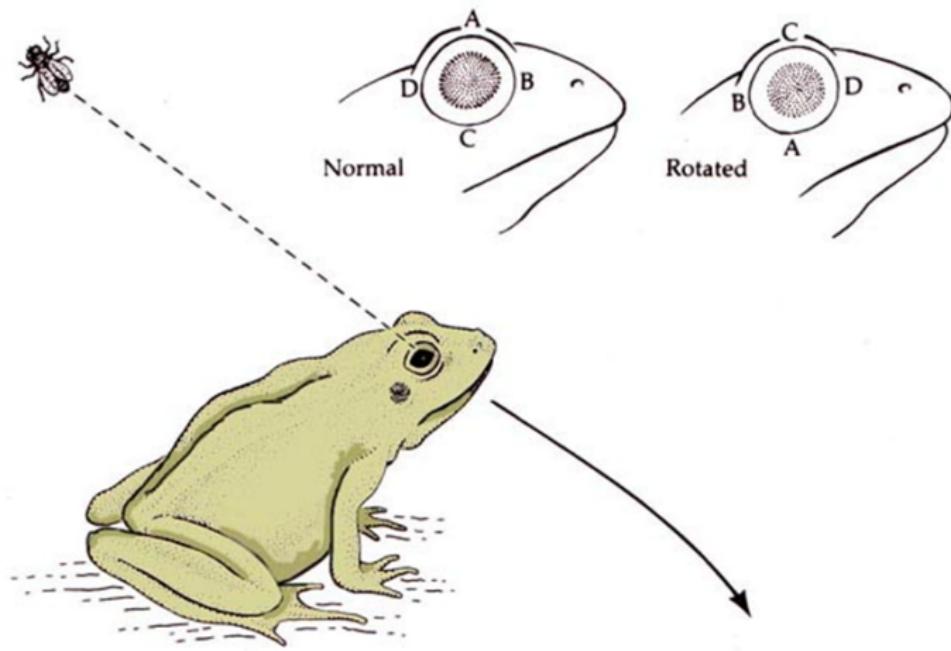
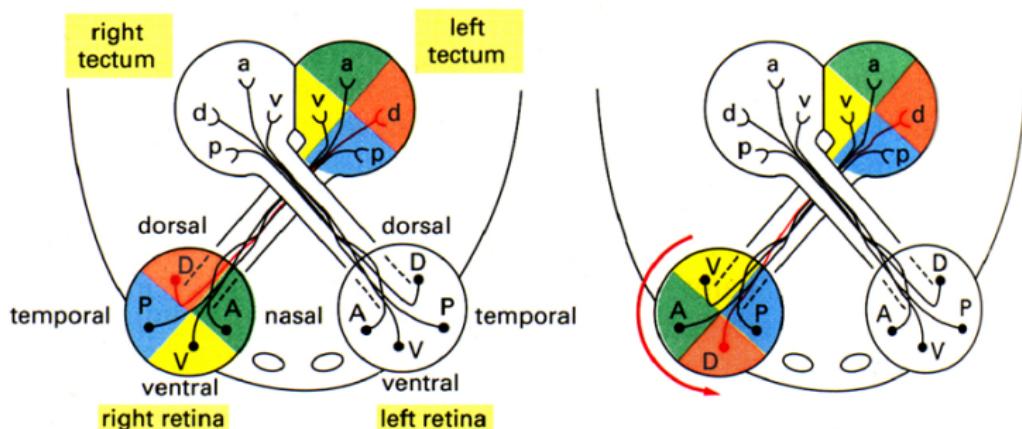


Fig. 21. When the eye is rotated 180°, the frog's prey catching behavior is inverted.  
(after Sperry, 1956).

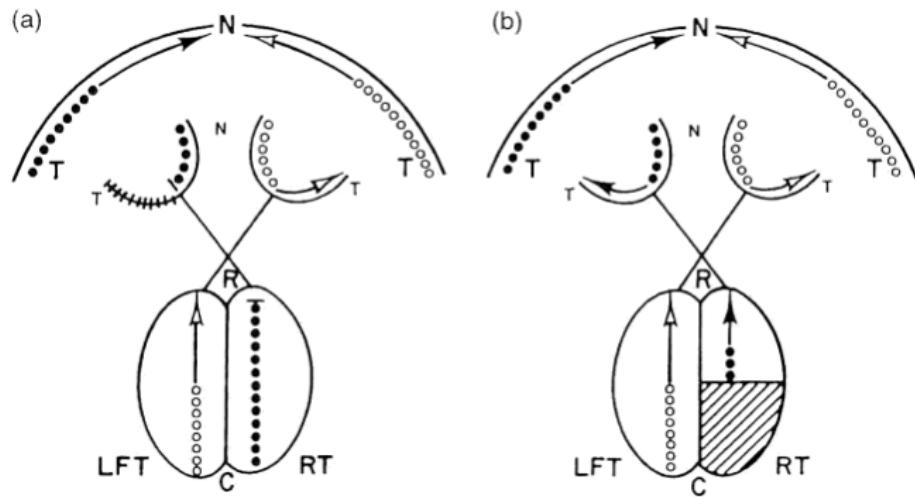
“...when a lure was presented in front of them ‘they wheeled rapidly to the rear instead of striking forward...’ and when the lure was presented above ‘the animals struck downward in front of them and got a mouthful of mud and moss.’ (Sperry, 1943)”

Sanes et al.



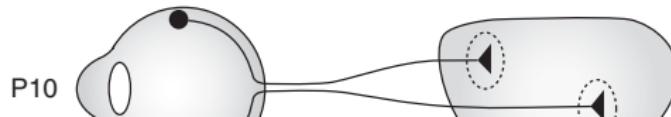
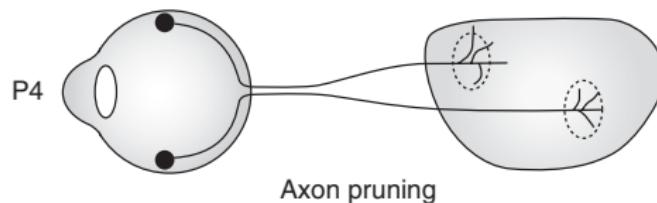
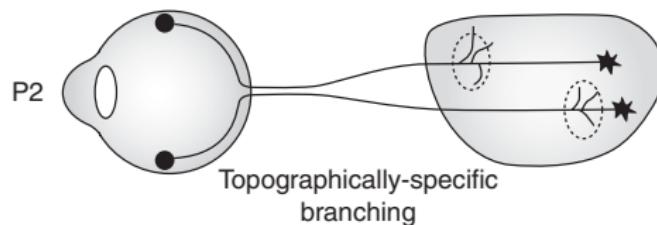
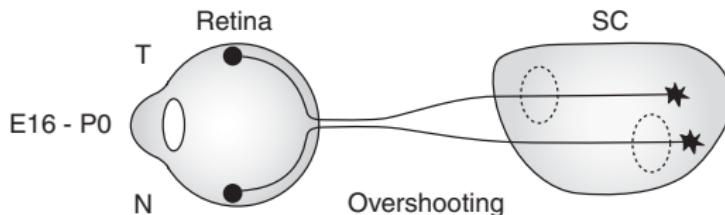
# Sperry's chemoaffinity hypothesis

Are labels rigid or plastic? Compensation experiments



# What other mechanisms might be involved?

(Feldheim and O'Leary, 2010)

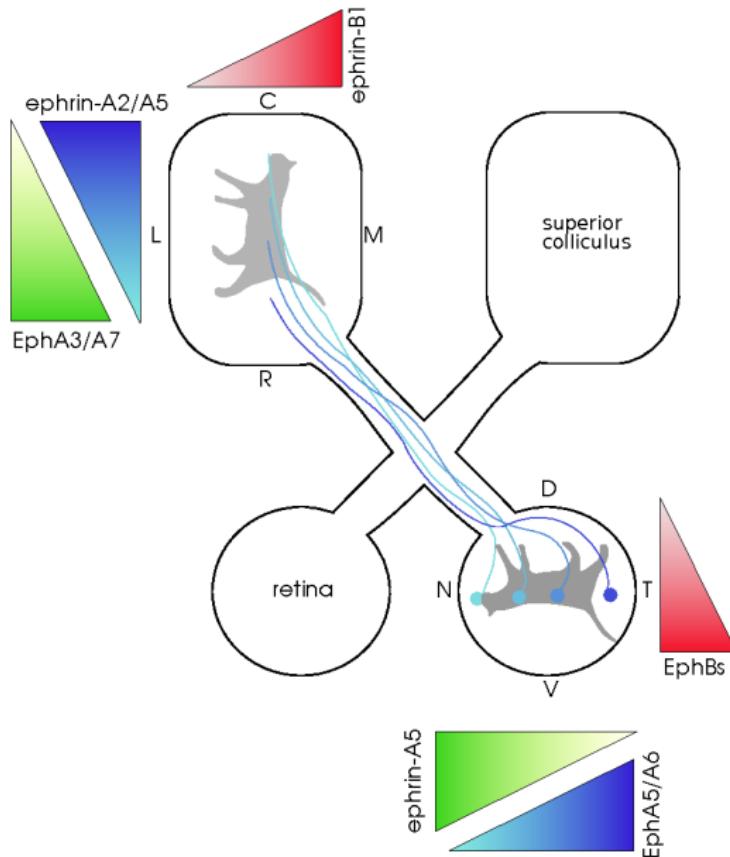


## Why build a model?

- Experiments test for necessity; models test for sufficiency.
- Moving from verbal to formal description of the process.
- Aims:
  1. account for experimental data
  2. predict outcomes of novel situations
  3. evaluate competing hypotheses
- Key success story: Hodgkin-Huxley modelling

## Eph receptors and ephrin ligands

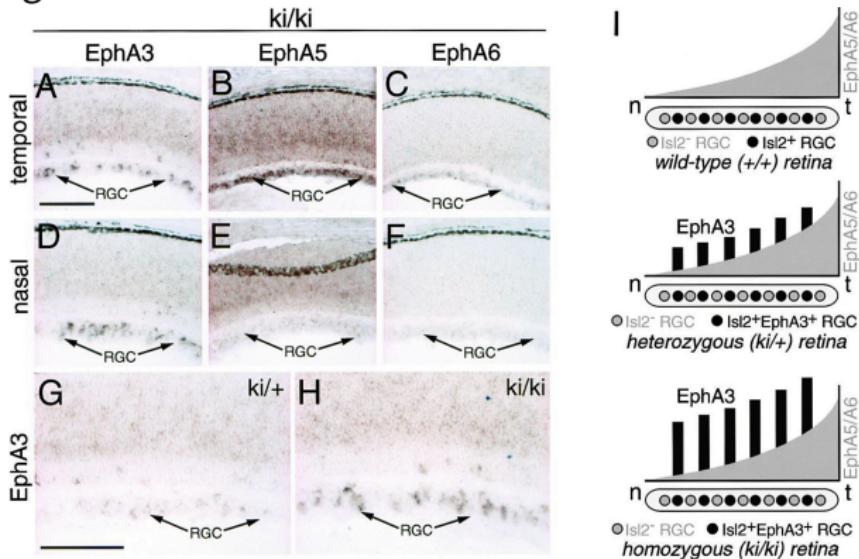
# Molecular gradients in the visual system



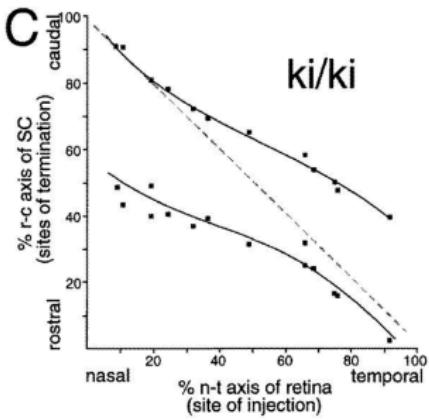
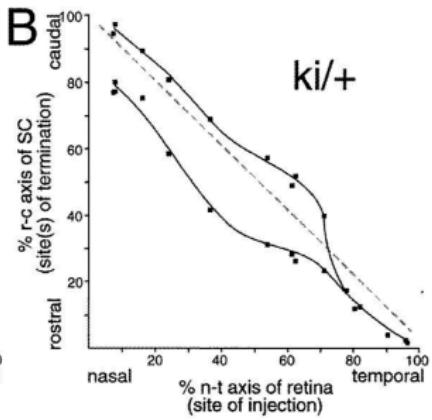
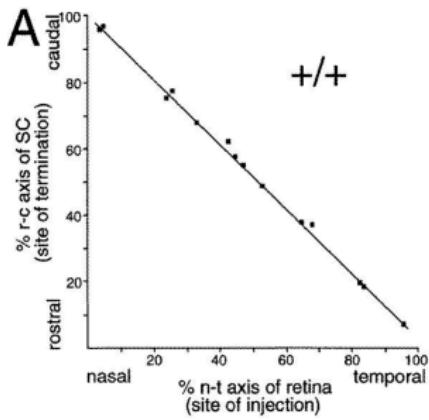
# Brown et al 2000: EphA3 meets Islet-2

EphA3 absent in mouse retina.

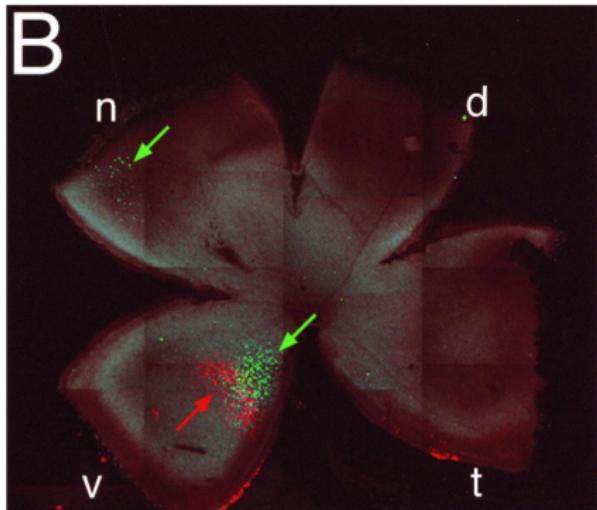
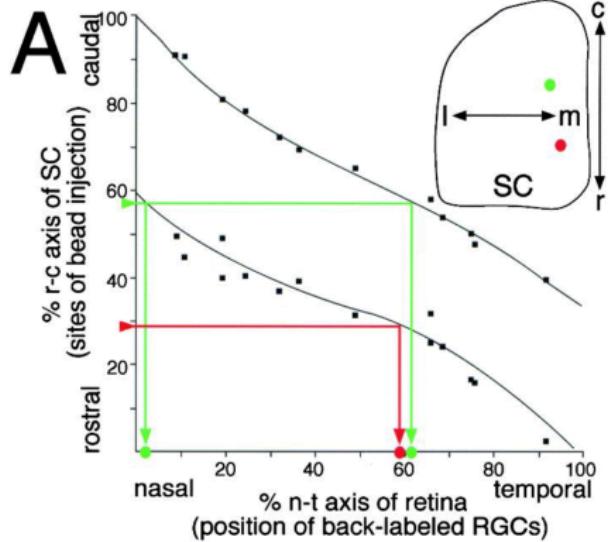
Islet-2 present in 50% of RGCs, randomly located throughout retina. Islet-2 + EphA3 mouse generated.



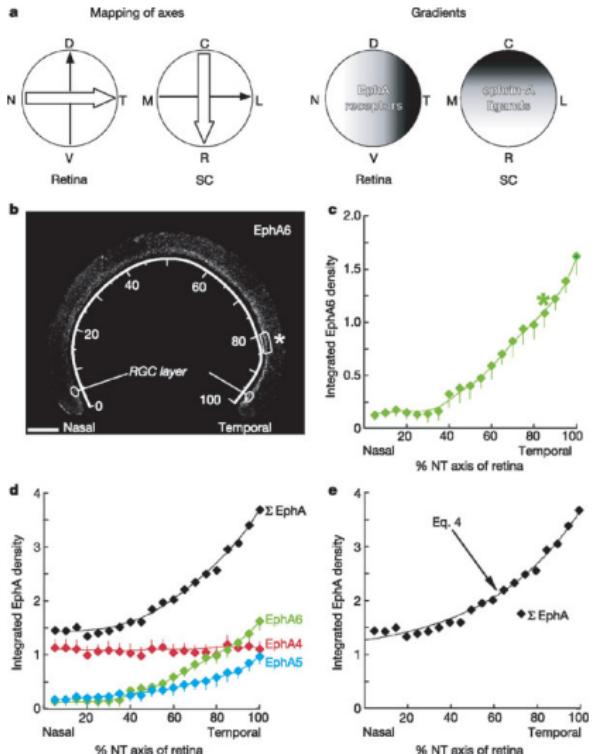
# Brown et al 2000: anterograde injections



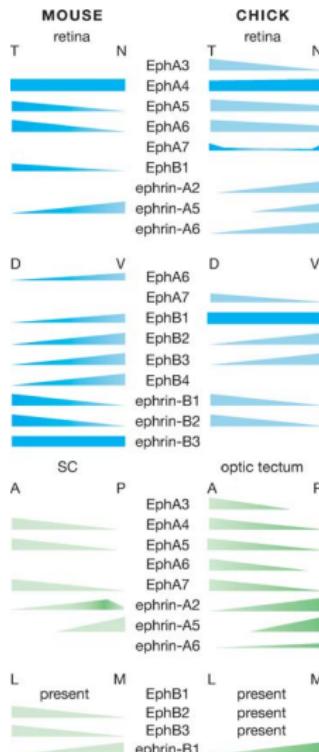
# Brown et al 2000: prediction for retrograde injections



# Expression of EphA mRNA in P1 mouse (Reber et al 2004)



# Catalogue of gradients (McLaughlin & O'Leary 2005)



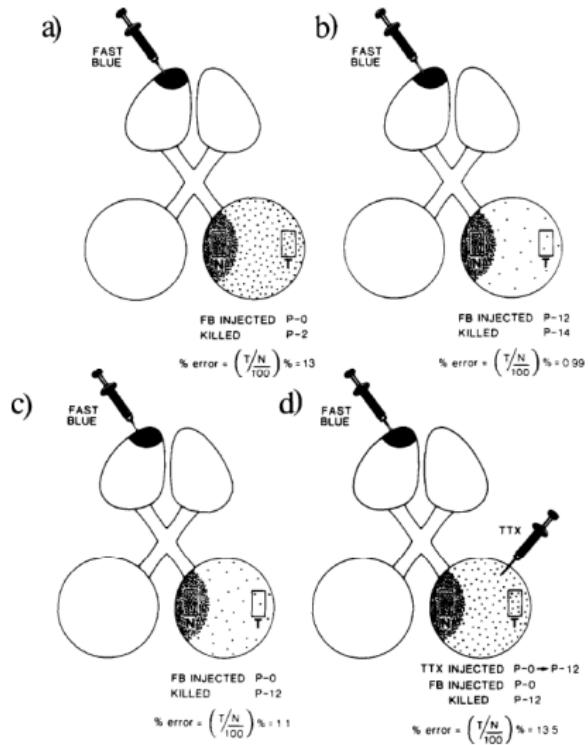
## Role of neural activity

## Neural activity as a cue

- Nearby retinal neurons might fire together to encode spatial relationships (Lettvin, cited in Chung, 1974).
- Nearby retinal neurons: fire in synchrony.
- Distant retinal neurons: fire out of synchrony.
- Likely to be the case for visual scenes.
- But many connections stable before vision is possible. Where might activity come from?
- Typical approach: strobe-rearing, TTX ...

# Activity-blockade experiments

(Fawcett 1985)



# Retinal waves (Wong et al. Neuron 1993)

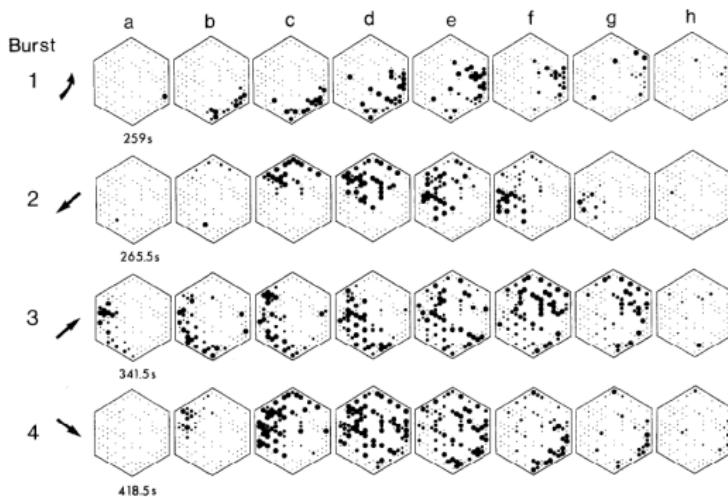
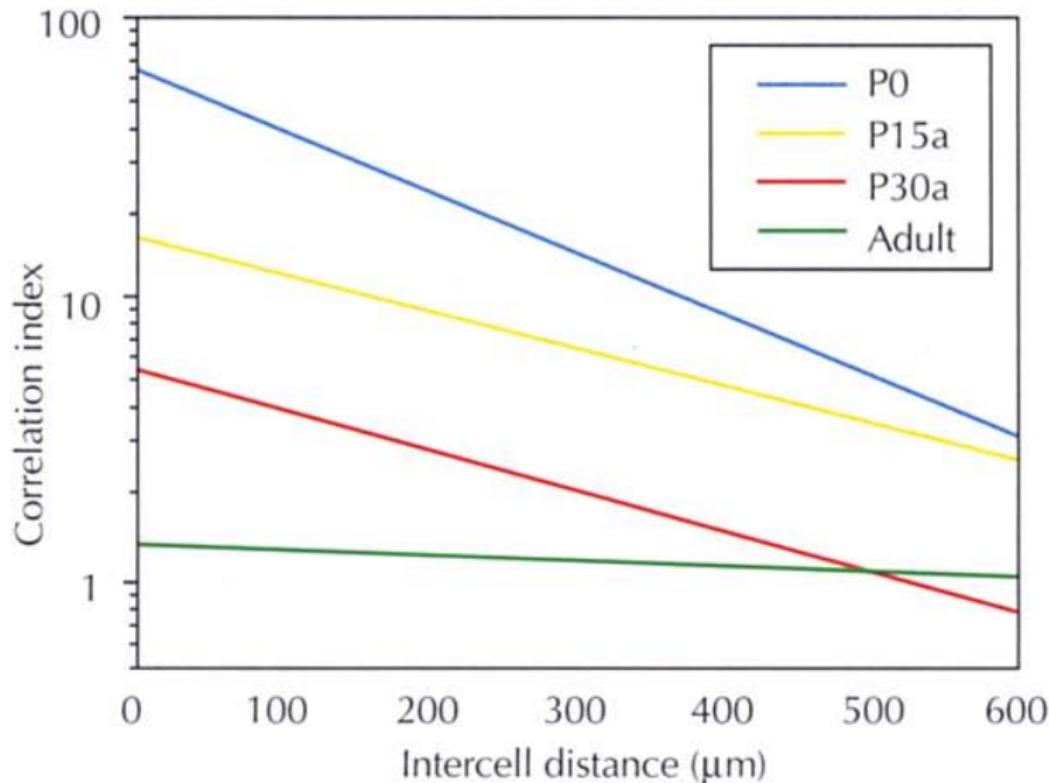


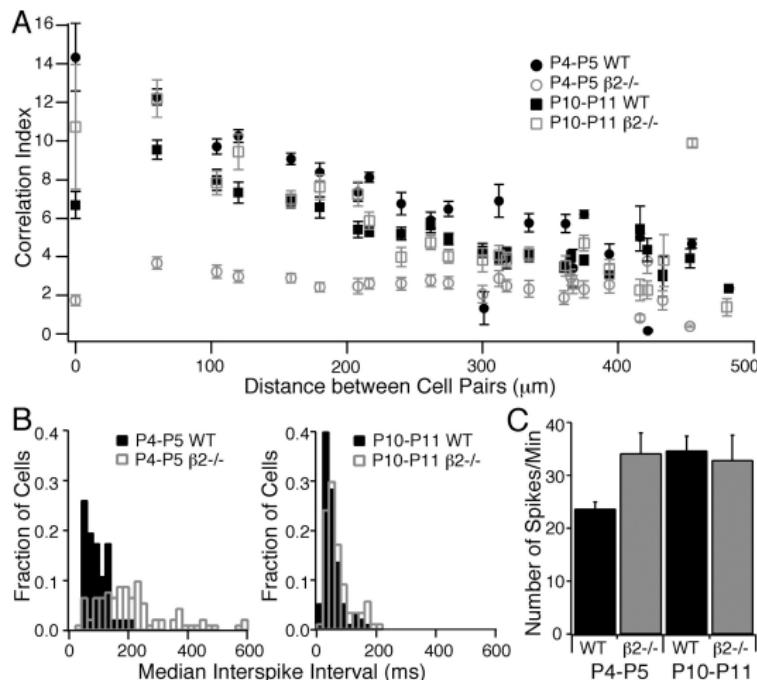
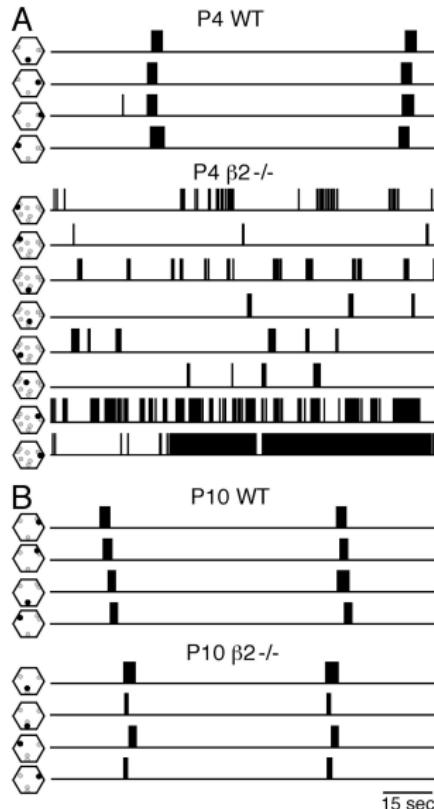
Figure 2. Spatial Progression of Spontaneous Activity during Four Consecutive Bursts from a P5 Retina

## Developmental reduction in correlations (Thompson, 1994)

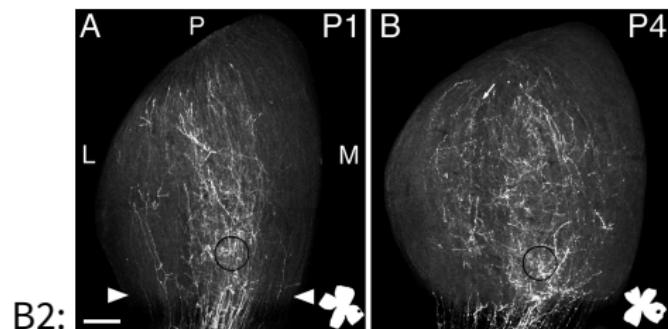
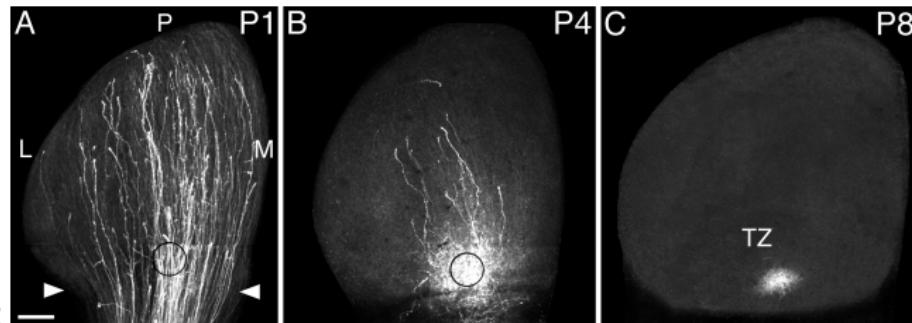


# Is activity permissive or instructive?

B2 mouse (McLaughlin et al 2003) cf. Stafford et al (2009).



## McLaughlin et al (2003) anterograde injections



## Summary

- Retinotopic maps
- Plasticity
- Gradient system: global order?
- Role of activity: fine scale?
- Next topic: segregation of inputs.