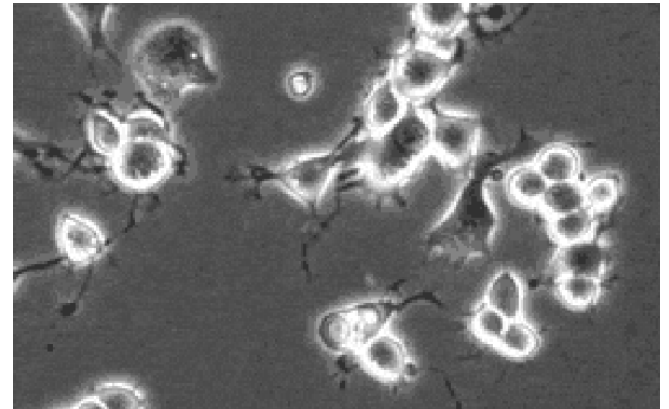


Visual development

- Where does visual system structure come from?
- How much of the architecture is specific to vision?
- What influence does the environment have?
- How plastic is the system in the adult?
- Most visual development studies focus on cats and ferrets, because they are born with very immature visual system.

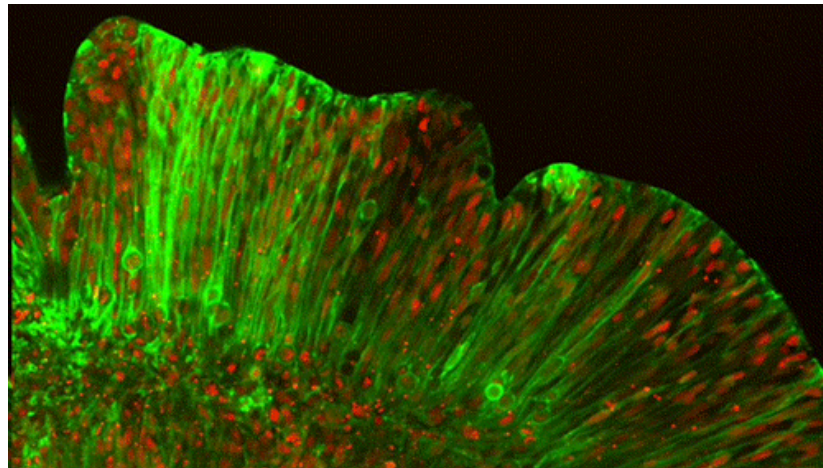


Stages of development

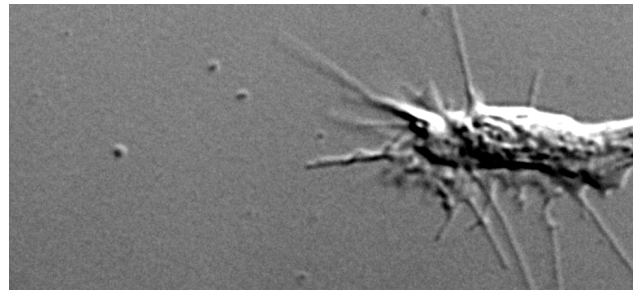
- Genetic vs. experience based
- Pre-natal vs. post-natal
- Molecular vs. activity based

Genetic development

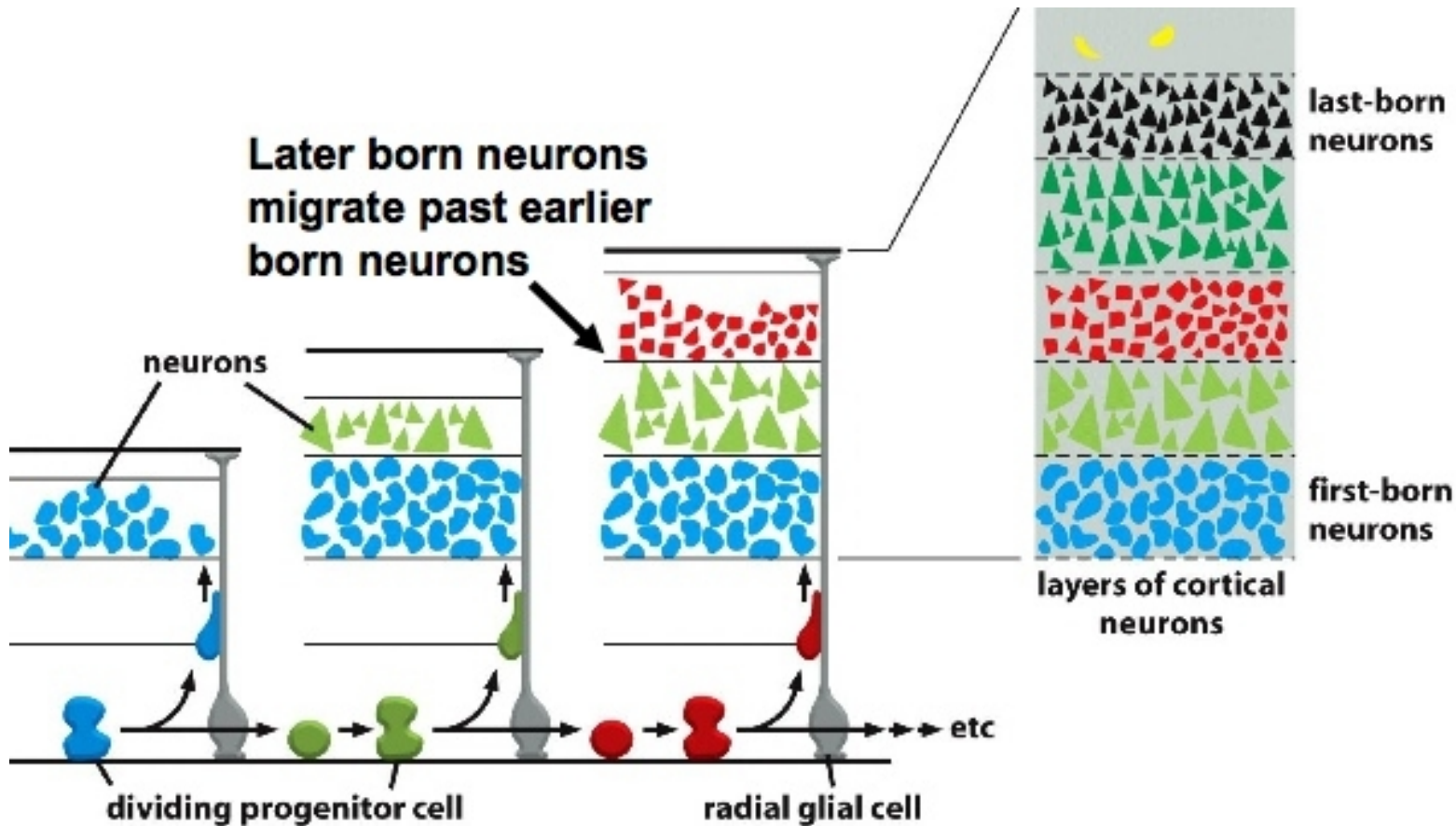
- Cell migration and placement



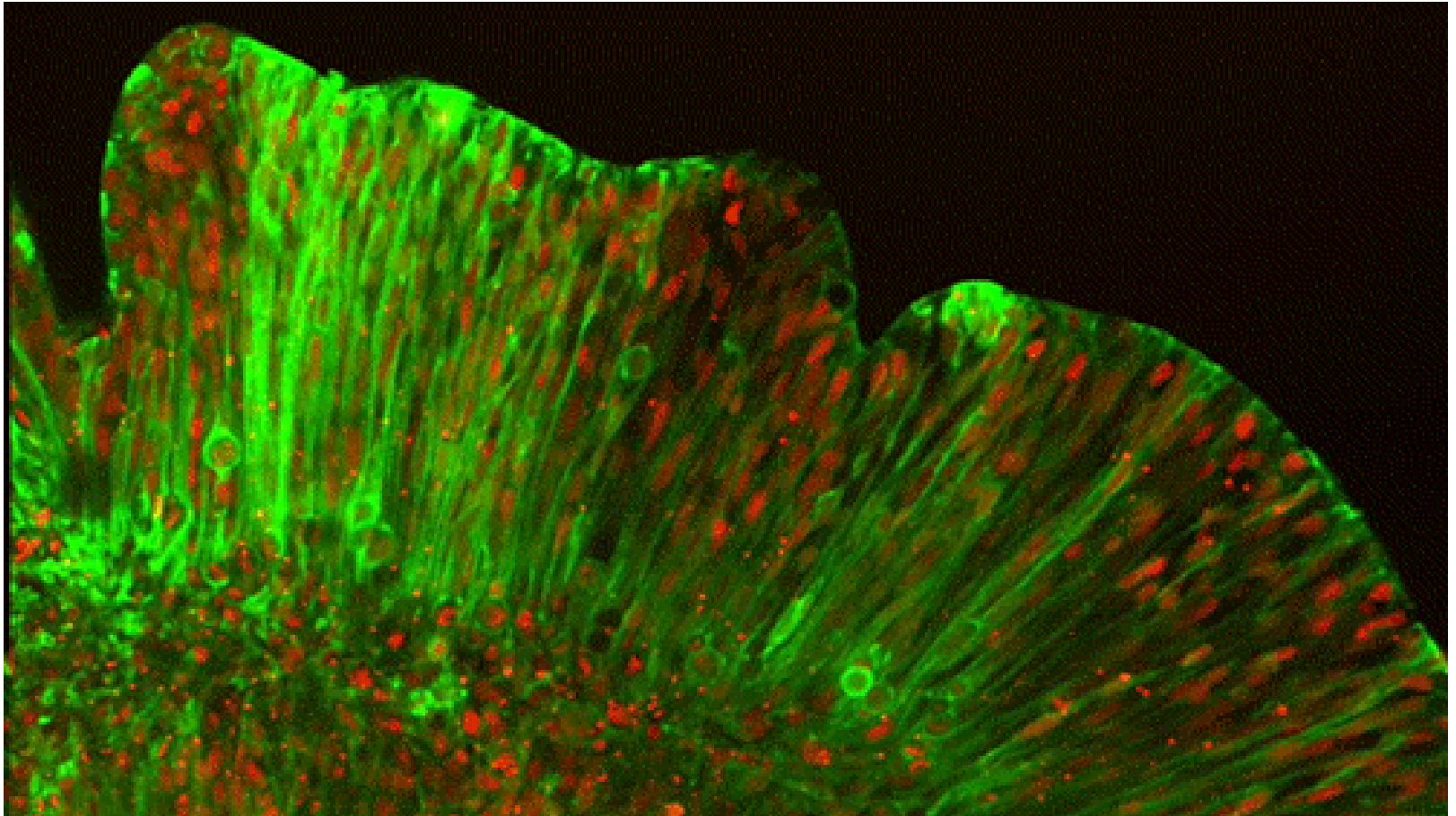
- Axon growth and formation of synapses



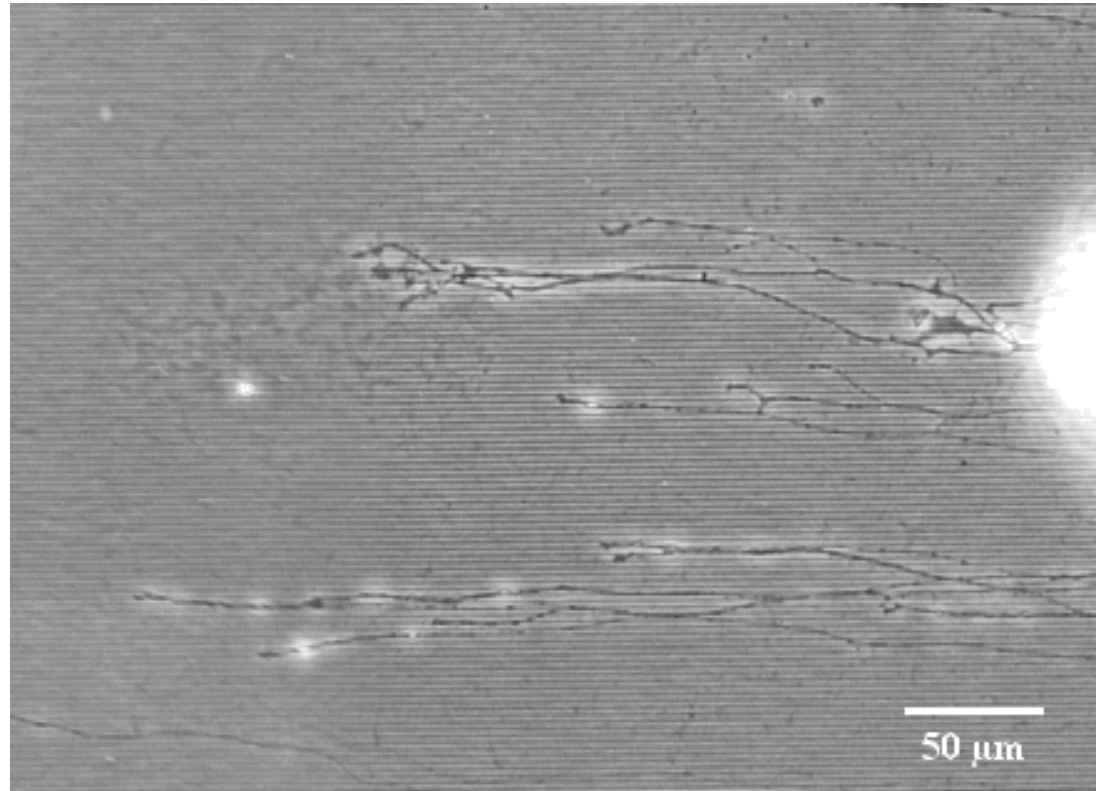
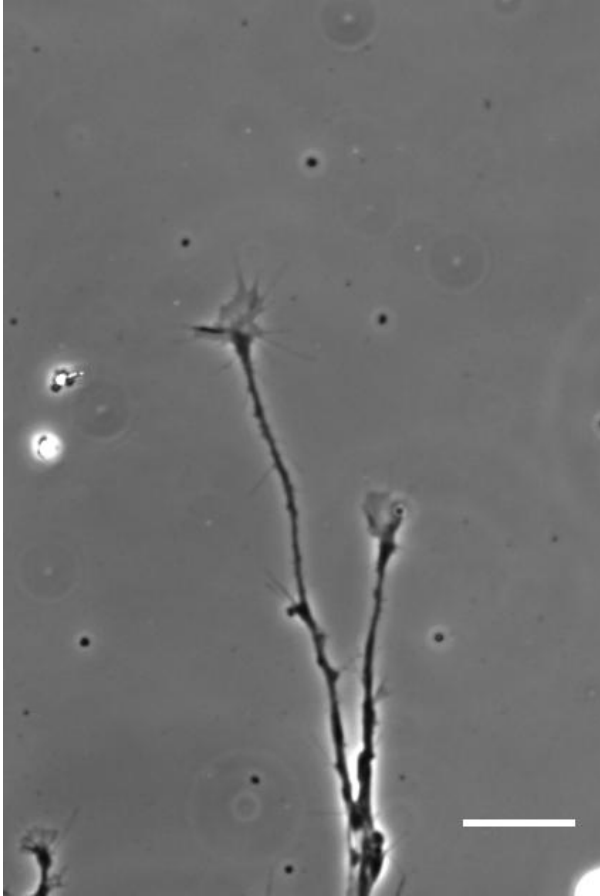
Cell migration and cortical scaffold

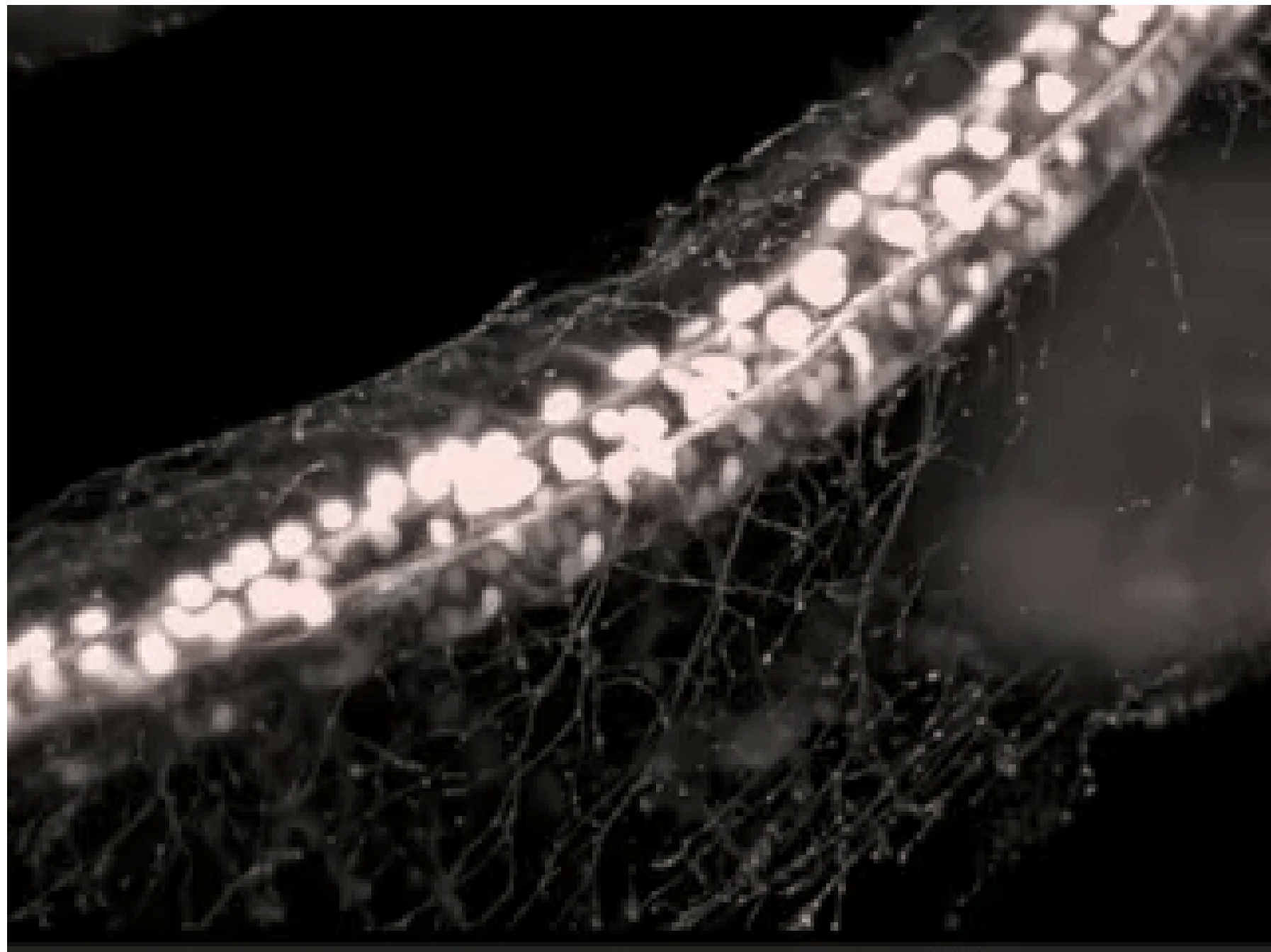


Cell migration and cortical scaffold



Axonal growth & tropic factors





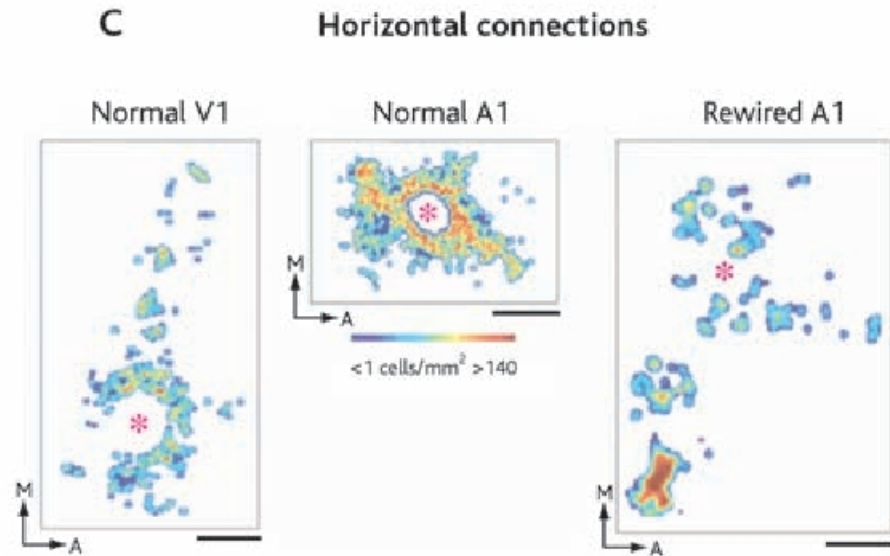
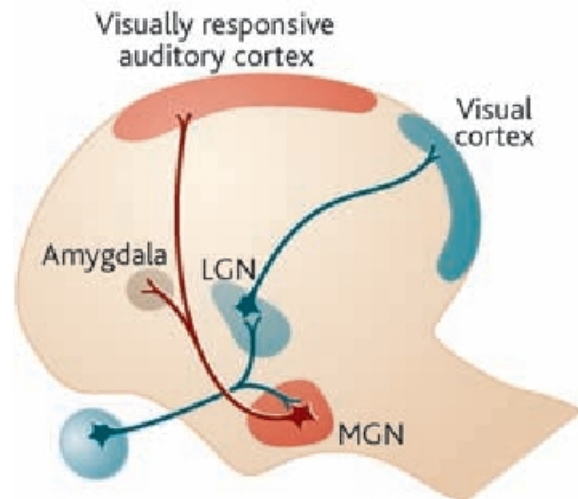
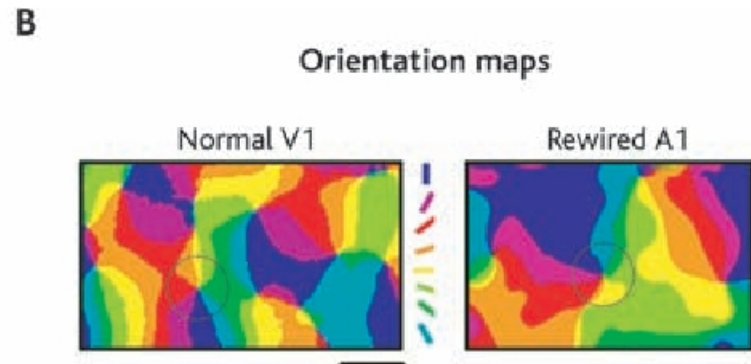
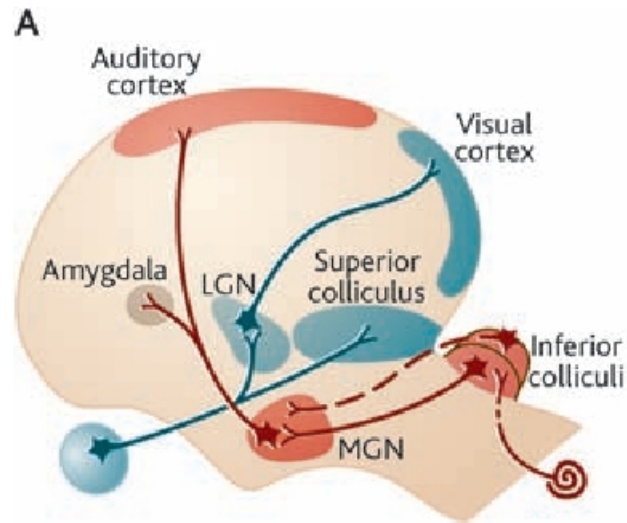
Visual system: development

- Tissues develop into eye and brain
- RGC axons grow from eye to LGN and superior colliculus following chemical gradients
- Axons form synapses at LGN, SC
- LGN axons grow to V1, V2, etc. , forming synapses

Cortical development

- Coarse cortical architecture (e.g. division into areas) appears to be genetic and fixed at birth
- Fine cortical architecture statistically similar across areas
- Details of connectivity differ by area
- Differentiation appears driven by different peripheral circuitry (auditory, visual, etc.)

Rewired Ferret



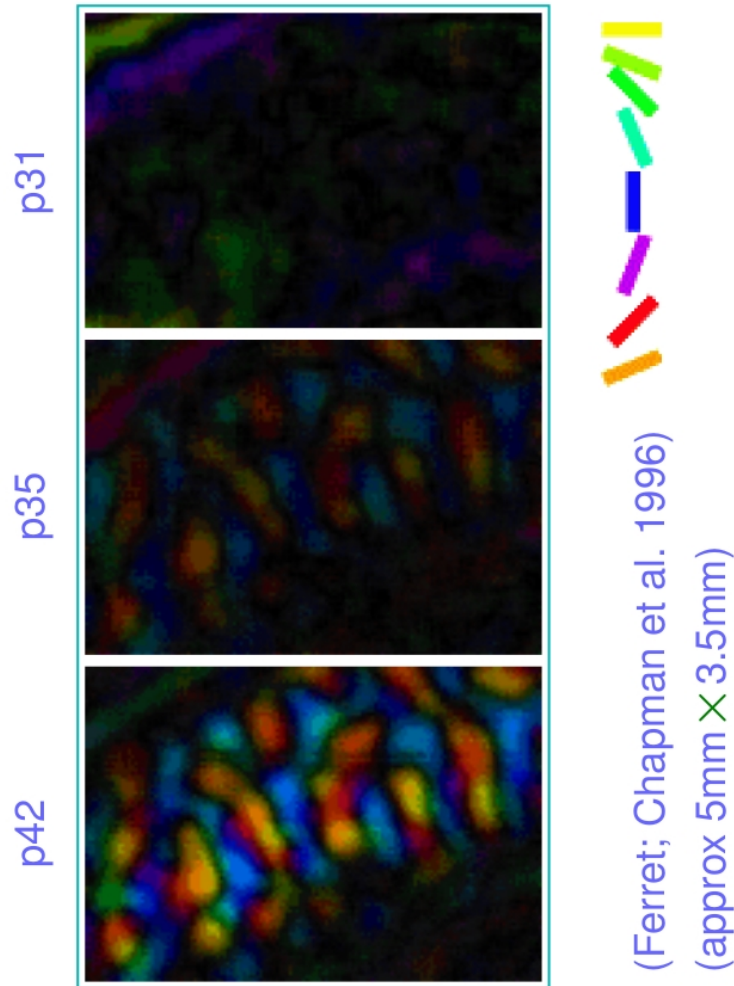
Human visual system at birth

- Some visual ability
- Fovea barely there
- Color vision poor
- Binocular vision difficult
 - Poor control of eye movements
 - Seems to develop later
- Acuity increases 25X (birth to 6 month)

Map Development

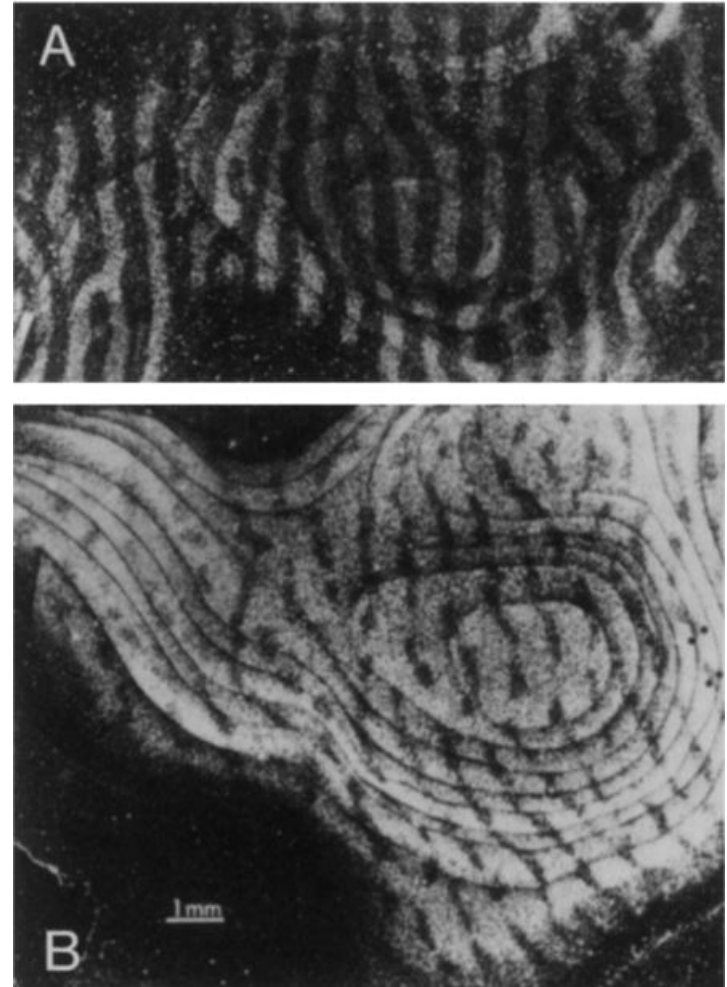
- Initial orientation, OD maps develop without visual experience (Crair et al. 1998)
- Maps match between the eyes even without shared visual experience (Kim & Bonhoeffer 1994)
- Experience leads to more selective neurons and maps (Crair et al. 1998)
- Lid suture (leaving light through eyelids) during critical period destroys maps (White et al. 2001)
- Complicated interaction between genetic development and environment.

Orientation map development



- Map not visible when eyes first forced open
- Gradually becomes stronger over weeks
- Shape does not change significantly
- Initial development affected little by dark rearing

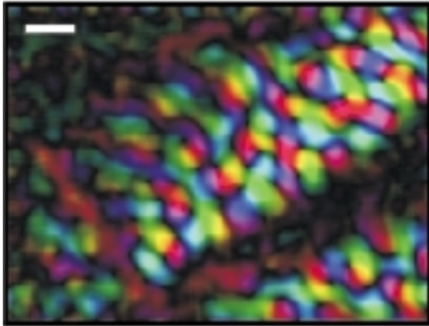
Monocular deprivation



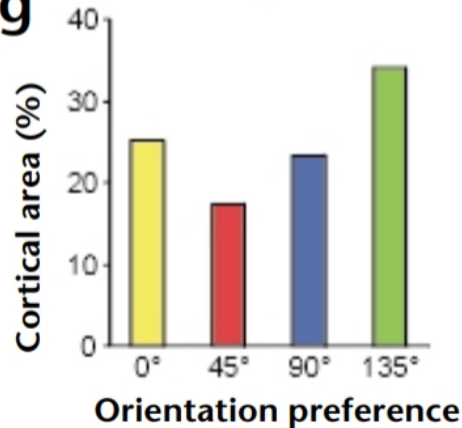
Monkey V1, Wiesel 1982

Orientation bias during development

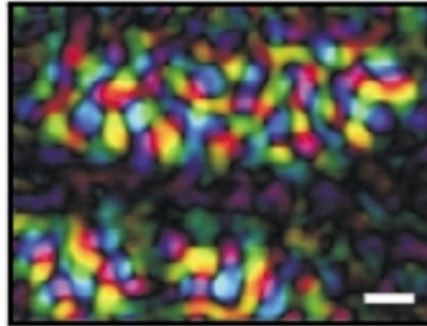
d



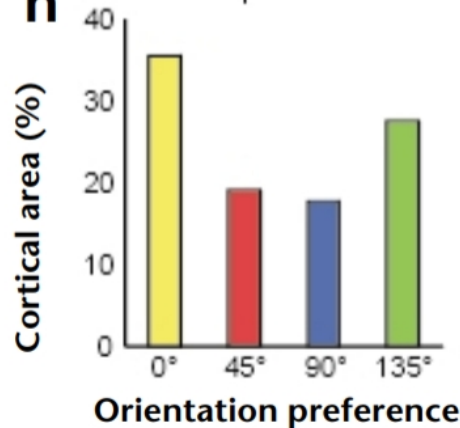
g



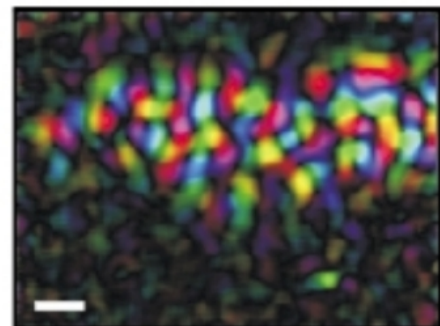
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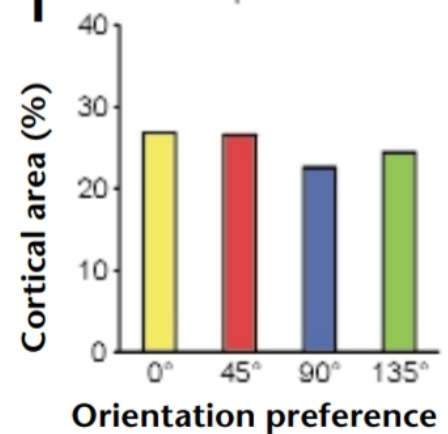
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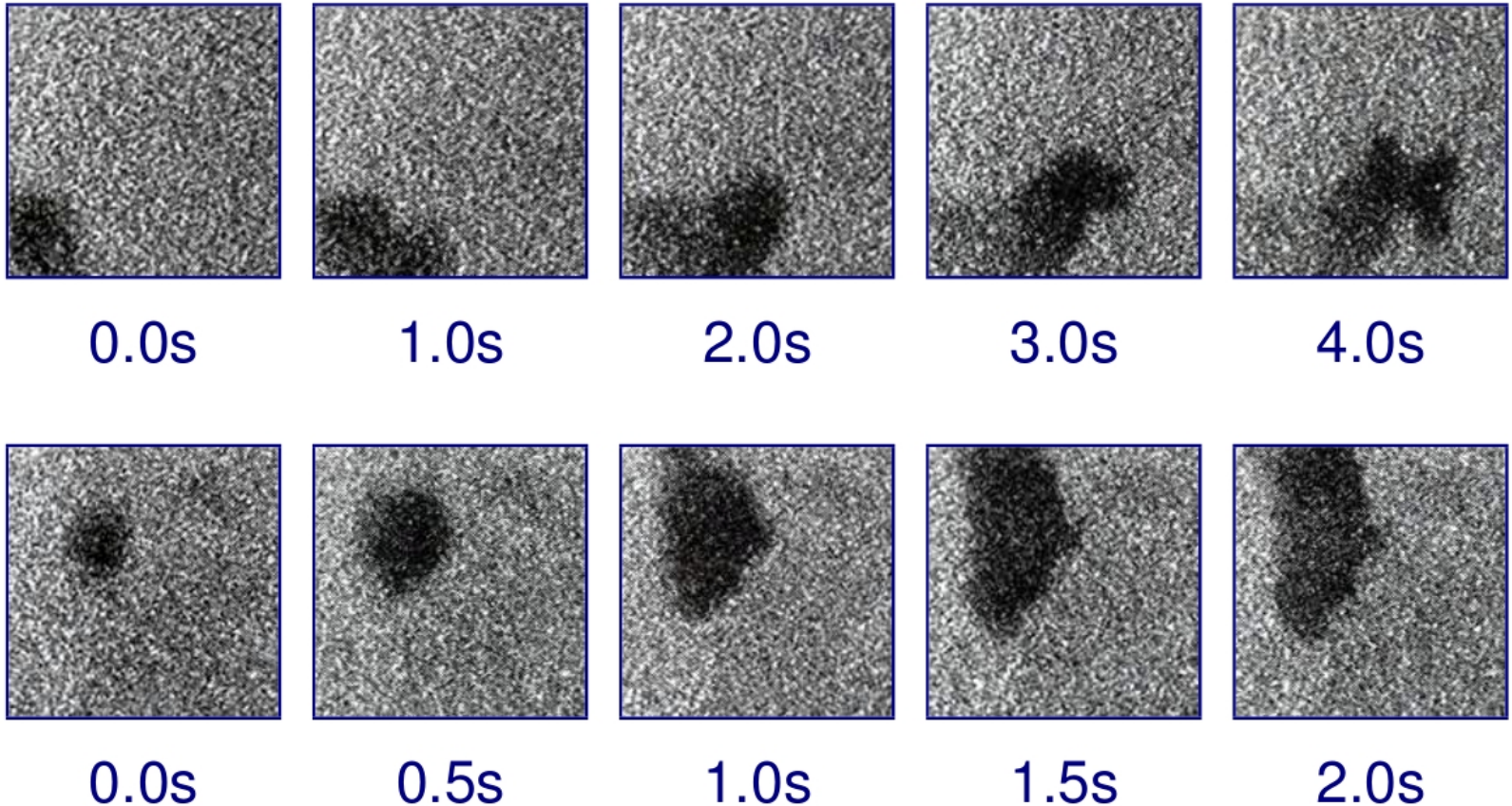


i



Cat, Sengpiel et al. 1999

Internally generated inputs



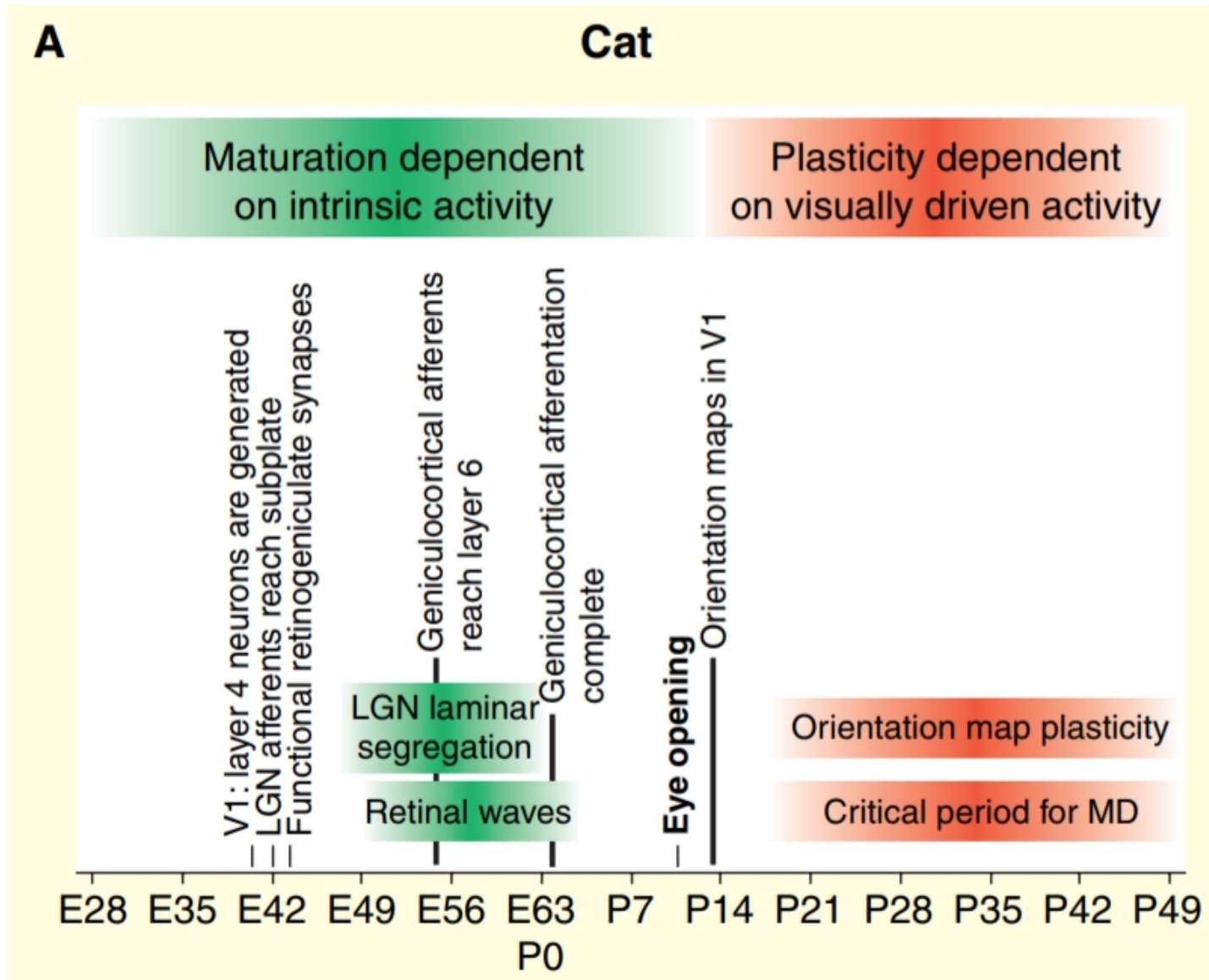
(Feller et al. 1996, 1mm² ferret retina)

- Retinal waves: drifting patches of spontaneous activity
- Training patterns?

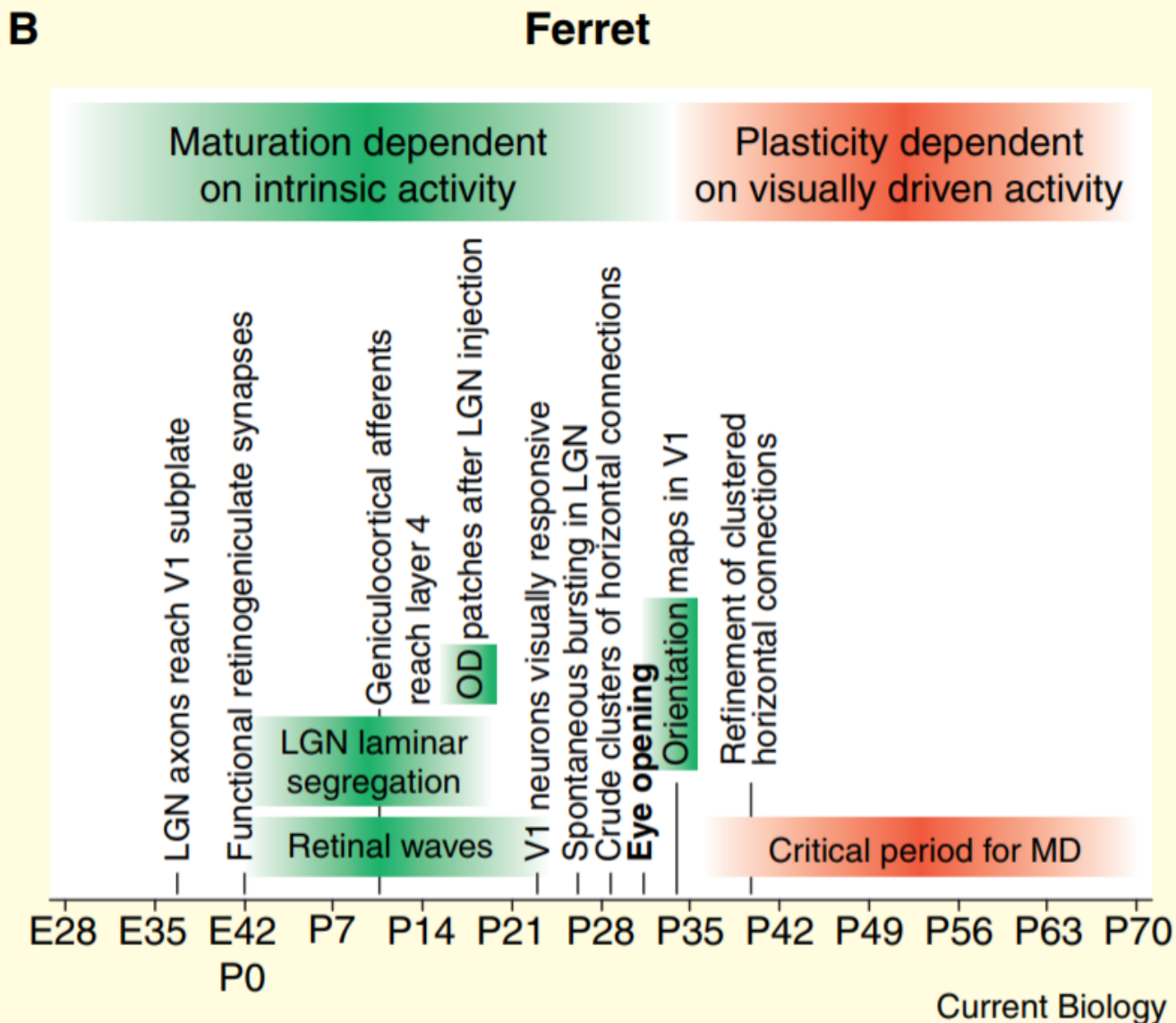
Role of spontaneous activity

- Silencing of retinal waves prevents eye-specific segregation in LGN (Huberman et al. 2003) and ocular dominance columns in V1 (Huberman et al. 2006)
- Boosting in one eye disrupts LGN, but not if in both
- Disrupting retinal waves disrupts geniculocortical mapping (Cang et al. 2005)
- Other sources of input to V1: spontaneous cortical activity, brainstem activity
- All developing areas seem to be spontaneously active, e.g. auditory system, spinal cord

Timeline: Cat

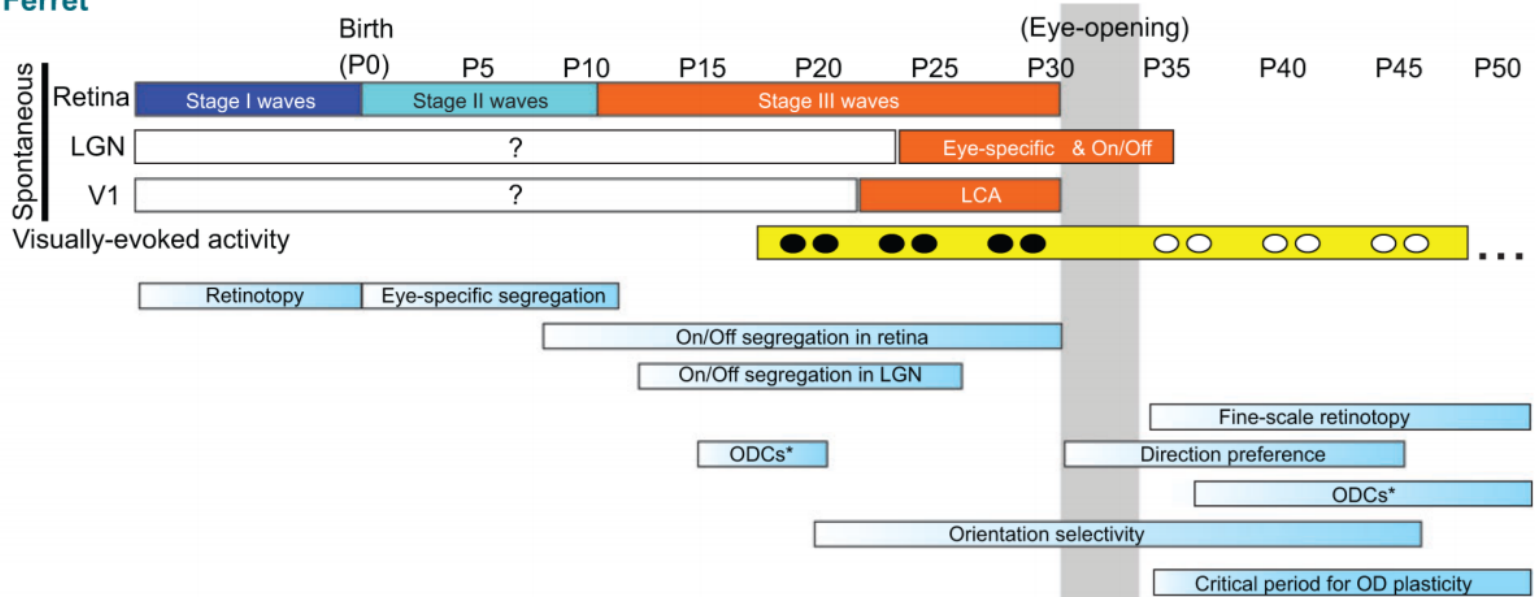


Timeline: Ferret



Ferret vs. mouse

Ferret



Mouse

