structural plasticity: 4/26/04

1. neurotrophin hypothesis: synaptic connections need strong activity (postsynaptic releases retrograde signals) so connections can thrive (eg BDNF retrograde signal)
   - if oversupply these molecules or knock out trkRs, don't get columns
2. LTP hypothesis: LTD (inhibits synapses); implicates NMDARs (Ca^{2+} influx, triggers LTD)
   - if synapse very active, Mg^{2+} block removed
     - often postsynaptic cell gets lots of inputs from same eye (get LTP), synapses grow
     - if several ~~long~~ pulses, no LTP, removes AMPARs (low Ca^{2+}), synapses retract
       ↳ low frequency, asynchronous ? (activates phosphatases)

- w/ monocular deprivation, before structural changes, synapses silenced within hours (may be LTD)

- critical period varies between organisms
  - LTD much less robust in mature animal (less plasticity)

- neurons that fire ~~together~~ wire together
  neurons that fire out of sync lose their link

receptive field:
- only small ~~numbers~~ number of triggers allow neuron to fire

- visual system has incredible ability to adapt to variety of stimuli
  - can detect $1 - 10^8$ photons/sec: very sensitive

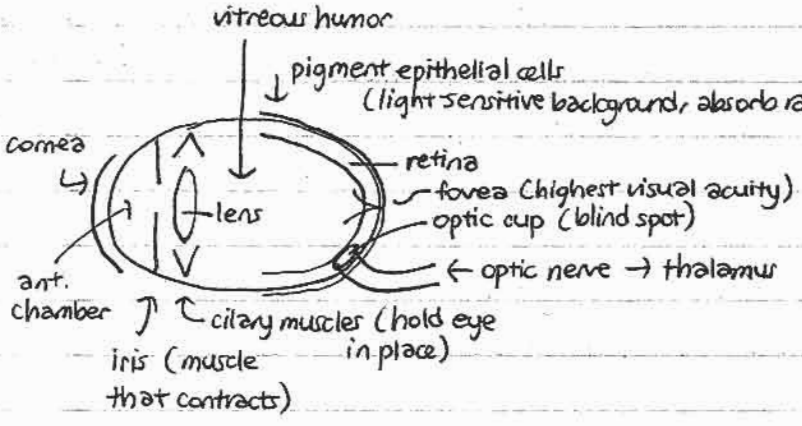
visual system properties:
1. sensitivity
2. receptive field (what required to activate neuron you're recording from)
   - hierarchy: neurons begin to integrate more & more complex information
3. lateral inhibition: contrast (neurons like to see boundaries)

1930's: Hartline studied horseshoe crab (Limulus): have many ommatidia, each sends one axon to optic nerve
- normally active, shining light makes very active: if shine on one area, area next

to it (neighboring photoreceptors) shut off

3 types of contrast:

1. spatial contrast: boundaries
2. temporal contrast: if slowly increase light intensity, hard to detect, but if fast, very detectable
3. motion: spatial & temporal

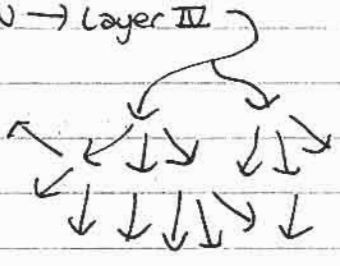


(this connection always fires in dark: light makes it stop firing)

photoreceptor receives light → bipolar neuron → ganglion cell → LGN → Layer IV

don't fire APs: use graded potentials

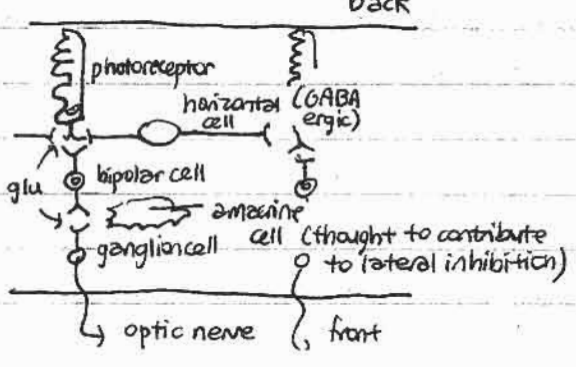
(optic nerve from these axons)



- as progress through visual system, receptive fields get bigger
  - retina 1 pt, bipolar neurons receive inputs from more than one photoreceptor, etc
  - in cortex, PC: face detection (extract information you want, ignore all else)
    MT: motion

anatomy of retina: crystalline

horizontal cells mediate lateral inhibition

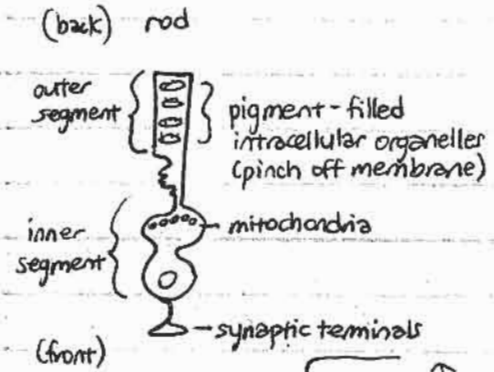


light must travel through all these cell types: in fovea, everything shifts so photoreceptors directly exposed

2 types of photoreceptors:

- rods outnumber cones 20:1

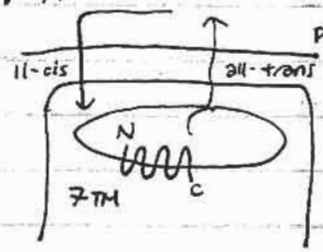
	rods	cones
number	20:1	
	night vision (1 photon)	daytime (10's - 100's photons)
	convergence (rods → bipolar)	talk to bipolar cells ↑ couple input on one
	10^8 photopigment/cell	
		good at acuity (b/c less convergence)
		fovea has only cones
	only one form of opsin (achromatic)	3 different opsins (color vision)
	~100ms (long signal processing time)	
	detect 12 Hz flicker	detect 55 Hz flicker



cone

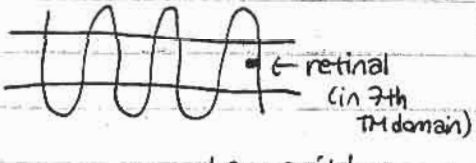
not pinched off

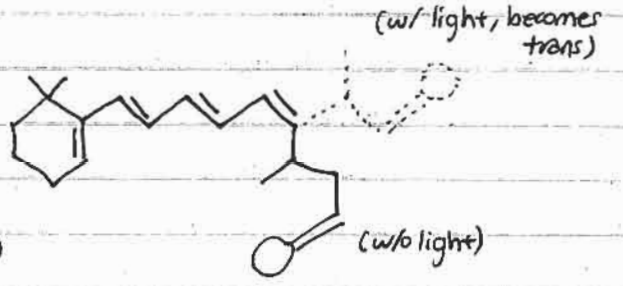
?



lys 296 in TM domain directly connects to 11-cis retinal

- rhodopsin





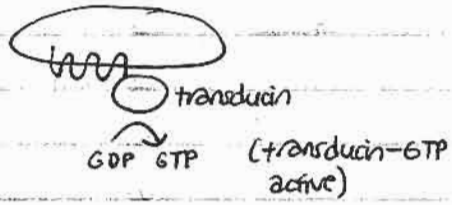
trans switches to active opsin conformation so c-terminus can interact w/ downstream proteins

different opsins hold retinal in slightly different conformations, so different λs change double bond

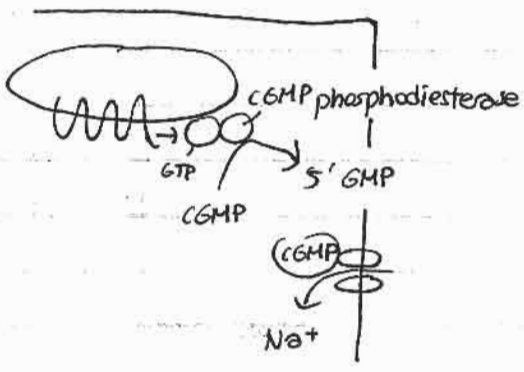
all-trans retinal transported out of cell to pigment epithelium, back to cis's, back to photoreceptors

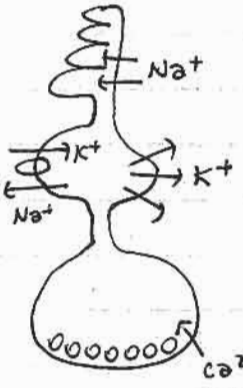
- 11-cis retinal from vitamin A (lack → night blindness, photoreceptor degeneration)

- rhodopsin is 6 protein-coupled receptor
  - when rhodopsin activated, recruits transducin



photoreceptors have no voltage-gated Na^+ channel, but have cGMP-gated Na^+ channel
(in dark, constantly fluxing Na^+ in)



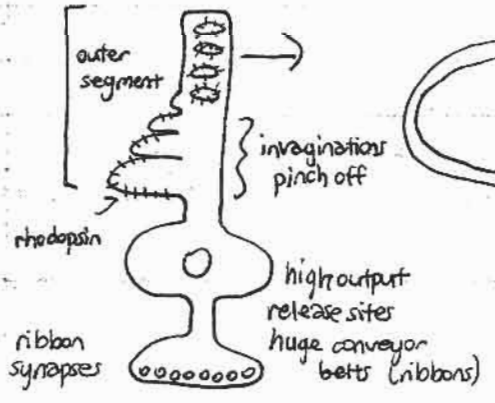


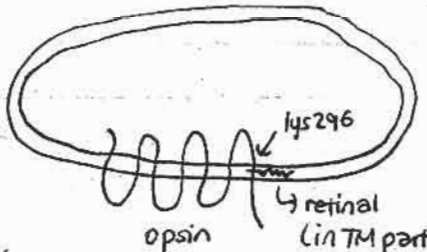
$E_K = -70$ mV
when Na^+ channels closed, hyperpolarize to −70 mV, } w/ light
no more synaptic transmission

(in dark, $V_m = -40$ mV)
−40 → −70 = dynamic range of vision

amplification:
- one activated rhodopsin can bind hundreds of transducins, 1:1 phosphodiesterase, but phosphodiesterase can convert 10^3 cGMPs
  - 10^5 amplification (can get dramatic response b/c of this)

rhodopsin = opsin + 11-cis retinal





(w/ light → change, active (must be deactivated to stop, w/ or w/o retinal)