Vision:

- Rods:
  - They're simply very specialized nerves that's able to take in light and convert it into a neural impulse
  - Have a bunch of optic discs
    - Embedded in the membrane of each optic disc are proteins (rhodopsin) that absorb the light and begin the phototransduction cascade that leads to the nerve firing
  - About 120 million per retina
    - The retina is the membrane that coats the back of the eyeball
    - Rods are found in the ***periphery* of the eyeball**
  - **Do not encode color vision, but are much more sensitive to light (1000 times more so than cones)**
    - Basically responsible for telling us whether or not light is present
  - **Low acuity** in rod circuit – light stimulus can only be pinpointed with the precision of 8 (arbitrary example) rod lengths
    - **High convergence (larger collection)** – several rods connect to several bipolar cells, which together connect to one retinal ganglia cell in the circuit; *not a 1:1:1 ratio as in the cone circuits*
  - Very slow recovery time
    - As soon as a rod is activated by a ray of light, it takes a lot longer for the rod to fire another AP than it does for a cone
- Cones:
  - Also specialized nerves that have the same internal structure as rods
    - In cones, photopsin protein is located in the optic disc membranes – it's almost identical to the rhodopsin in rods
  - Only about 6 million cones per retina
  - **High acuity** in cone circuit – light stimulus can be pinpointed by the width of one cone
    - **Low convergence** – one cone to one bipolar cell to one retinal ganglia cell per cone circuit
  - There's a region of the retina that dimples in, called the ***fovea***
    - Cones are located mainly in this region
      - ***Centered near the fovea***
        - ***Fovea is the part of the eye that allows us to see really fine detail***
  - ***Produce color vision***
    - ***Not as sensitive to light, but do result in color vision***
      - ***Red cones – 60%***
      - ***Green cones – 30 %***
      - ***Blue cones – 10%***
  - Faster recovery time
    - Rapidly adapt to changes in illumination

- Phototransduction cascade: the process of turning the rod from on to off
  - Light enters the eye and hits the retina first
    - Basically a set of things that occur as soon as light hits a rod or a cone
  - When the rod is turned off, it turns on a bipolar cell
    - By the rod turning off by being exposed to light it turns on a bipolar cell, which turns on a retinal ganglion cell, which goes into the optic nerve and then enters the brain.
  - The bipolar cells with ionotropic glutamate channels will be hyperpolarized and inhibited by light
    - **Off-center bipolar cells**
  - Bipolar cells with metabotropic glutamate receptors will be depolarized by light
    - **On-center bipolar cells**
  - **Bipolar cells do not fire APs**
    - *Their depolarization/hyperpolarization modulates the amount of glutamate released onto the ganglion cells, which DO fire APs*
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- Distribution of photoreceptors
  - The part of the retina directly where the optic nerve exits the back of the eye is called the **blind spot – no photoreceptors are in this area because this is where the optic nerve is exiting**
  - **Rods –** located in the periphery of the retina
  - **Cones** - located near the **fovea (dimple)**
    - Why does the fovea dimple?
      - The photoreceptors are connected to other neurons that send axons through the optic nerve into the brain, exiting from the back of the eye
        - There **are no axons in the way** of the light as it enters the fovea thanks to the dimple, giving you a **higher resolution**
- In the absence of light, photoreceptors release glutamate onto bipolar cells
  - In the dark, glutamate binds to **metabotropic** receptors on **ON-center bipolar cells**, which ***close*** *cation channels* through a cellular cascade; on-center bipolar cells are *inhibited* by photoreceptors in the dark
    - However, when light *does* hit the photoreceptors, less glutamate is released; thus, less glutamate binds to the metabotropic receptors on the on-center bipolar cells and ***less cation channels are closed***
      - Thus, the decreased binding of glutamate ***results in less hyperpolarization***
        - Because the cell is less hyperpolarized, more channels stay open and more glutamate is released to the ganglion cell

                - The retinal ganglia cells have ***ionotropic*** glutamate receptors, and when more glutamate binds to these receptors, the ***cell is depolarized and an action potential occurs***
                    - **NOTE: bipolar cells DO NOT fire APs; retinal ganglion cells do**
- **Receptive fields:** *Region of the retina which must be illuminated in order to obtain a response in any given fiber*
    - **For retinal ganglia cells, LGN cells, and primary visual cortex lower layer IV cells, receptive fields have the same properties:**
        - Circular
        - Monocular (for cells with circular fields)
        - Smaller in the fovea
        - Many include both an excitatory and an inhibitory area
        - They are also **concentric**: *center-surround shape*
    - **On-center cell receptive fields:**
        - When only the **center** is illuminated, firing frequency increases
            - *(Extra information)* Horizontal cells make a GABAergic synapse on the photoreceptors when the surrounding periphery is illuminated
                - The center is *not* illuminated, so MORE glutamate is released (as if it were dark)
                    - GABAergic synapses on the photoreceptor by horizontal cells *decreases the depolarization;* ***hyperpolarizes the photoreceptor***
                        - This *INCREASES* the amount of glutamate being released; it is as though the cell is polarized as it is in the dark
                        - When the cell is hyperpolarized, more glutamate is released and it binds to the metabotropic channels, closing the cation channels
            - Firing frequency *decreases* when the surrounding periphery is illuminated, but *increases when the light is turned off* (goes back to dark