**Virtual Class Notes: Tuesday, August 25th**1. Review of Thursday’s virtual class
**2. Discussion of light and refraction:** Light travels as photons on specific wavelengths. Higher energy photons travel on shorter wavelengths. Visual spectrum is 400 (violet) -700 nm (red). Light travels through the cornea and then the lens. Both structures serve to refract (bend) the light inward to an intersection of light waves on a point called the focal point. The distance between the center of the eye’s lens and the focal point is called the focal distance of the lens. Focal distance is influenced by how far the lens is from the object and the shape of the lens. A “rounder” the lens is, the shorter the focal distance. The flatter the lens, the longer the focal distance. The closer the source of the image (greater angle of light rays), the longer the focal distance. The more distant a source is (smaller angle of light rays), the shorter the focal distance.
3. Accommodation : automatic adjustment of the lens to provide focus
4. Visual Acuity: your vision vs “normal” standard …ex: 20:30 This person must be 20 feet away to see what someone who is 20:20 sees at thirty feet away

**5. Discussion of the retina:**outer pigmented layer absorbs extra light and prevents visual “echos”
inner neural layer composed of:
 photoreceptors (rods and cones), bipolar cells,
 ganglion cells, horizontal cells and amacrine cells.
photoreceptors:
 a. intrinsically photosensitive retinal ganglion cell )ipRGC: function to provide into
 for visual reflexes (pupillary dilation/constriction, circadian rhythm)
 b. rods: very sensitive to light but do not distinguish different wavelengths of light
 w/outer segment rod like
 c. cones: permit color vision by distinguishing between wavelengths of light and
 permit sharper images but require bright light to function w/outer segment cone
 like
Rods and comes contain visual pigments/rhodopsin located in the discs of their outer segments. Rhodopsin is composed of the pigment **retinal** (vitamin A derivative) and the protein **opsin.** Rods each have the same type of retinal and opsin…cones have different opsins depending if it is a red,blue or green cone and are sensitive to different wavelengths of light. Red cones are more numerous (74% are red…then blue…16% then green 10%).

**6. How do the photoreceptors work…?**Photoreceptors have gated Na+ channels in the membranes of their outer segments that are open when it is at rest (in the dark). **Cyclic guanosine monophosphate** **(cGMP)** keep these Na+ channels open. As Na+ enters the cell, the inner segment pumps Na+ out of the cell. Because the membrane potential of the cell is lower than that of a resting neuron (-40mv vs -70mv…mv = millivolt = 1/1000 volt) it is constantly releasing its **neurotransmitter glutamate** across its synapse to the neighboring bipolar cell. This is called the **dark current**. Da da da daaaaa.
**Rhodopsin** is bound to the membranes of the discs in the outer segment. Rhodopsin contains **retinal** which in the dark is in its ***cis*** form…the molecule has kind of a bend in it.
**Activation by light energy…**When light energy strikes the retinal, the retinal changes to its linear ***trans*** orientation.
 
FYI…(You can see in the pic above that in the cis configuration, both of the attached hydrogens are on the same side of the double bond while in the trans configuration, the hydrogens are on opposite sides of the double bond. A**bsorption of a photon promoted an electron to a higher-energy orbital which altered the double bond allowing the rotation about the bond between carbon atom 11 and carbon atom 12…hence conversion to *trans* orientation.)**This alteration of retinal starts a cascade of events…retinal’s partner opsin in the rhodopsin molecule is activated. Opsin then in turn activates **transducin,** a G protein imbedded in the membrane next to the rhodopsin. Transducin then activates **phosphodiesterase(PDE).** PDE breaks down cGMP. As the cGMP is degraded, the channels close and Na+ can no longer enter the cell. The dark current decreases. As this occurs, the membrane potential edges towards 70mv, the membrane hyperpolarizes, the amount of neurotransmitter released decreases. **It is the absence of neurotransmitter that signals the adjacent bipolar cell** that the receptor has been activated (photons have been absorbed from the light).
To revert back to the resting state, the *trans* form of the retinol can’t just revert back to *cis.* Instead, the entire rhodopsin has to be broken down into its opsin and retinal and then reassembled. This process is called **bleaching.** Bleaching requires energy in the form of ATP and it takes time. If you experience an intense flash of light or high beams in your face while driving at night, you see an afterimage. That’s because the system hasn’t reverted yet. During this regeneration, opsin is inactivated so the cGMP breakdown halts. As more cGMP is generated, the Na+ channels reopen and the cell resumes releasing neurotransmitter.

**7. How does Vitamin A play a role in vision?**Vitamin A is required for the production of rhodopsin. We store enough Vit A in our pigmented cells to last a few months. Discs at the base of the outer segment are made to replace older discs at the ends. They last about ten days before they are shed. The pigmented cells pick them up and recycle the retinol back into Vit A and store it to be transferred to the sensory cells for later use. Night blindness occurs when there is to little Vitamin A available and the rods are unable to be activated.

**8. Adaptation to light:**Dark-adapted state:
 Visual system easily stimulated. 30 minutes in a dark room permits all receptors to have recovered from bleaching. Think dark room into bright light. OW!
 Light adapted state: Rate of bleaching balances reassembling of pigments.
Response to bright light = pupils constrict and light entering eye is reduced 1/30.
Response to dim light = pupils dilate and light entering eye is increased X 30.

**9. Color vision:**3 cones types distinguish different wavelengths of light. All of the light spectrum stimulating all three cone types if perceived as white. We see what is bounced off of an object. Variations in color are combination of different cones being stimulated.

**10. What are bipolar cells and ganglion cells?**6 million bipolar cells and 1 million neurons serve to transmit information from the sensory neurons. Ganglion cells monitor their receptive field, an area of the field of vision. Hundreds of rods pass info via their bipolar cells to a single large ganglion cell called a magnus (M) cell. This convergence which provides info about general forms and shadows and movement. Despite the high level of convergence, ganglion cells can discriminate specifically where the light has activated sensory neurons…some detect light at the edges of their receptive field and some at the center. In this way, more info is sent to the processing center in the brain.
Cones lack convergence. There is a 1:1 ratio cones to their ganglion cells called parvo (P) cells. So cones can provide precise information (> resolution) about an image more so than rods.
Amacrine and horizontal cells: horizontal cells permit lateral communication between the rods and cones. Amacrine cells permit lateral communication between ganglion cells.

11. **Visual Pathway**: ganglion cells > optic nerve > optic chiasma > lateral geniculate body > optic radiation > visual cortex of optical lobe
Optic Chiasm sends info from left eye to right hemisphere and right to left. See pic.
Diencephalon/brainstem/hypothalamus also informed via collateral nerve fibers ex: reflexes requiring visual information and pupillary dilation/contraction
pineal gland received info to monitor circadian rhythm.