- When light moves from one medium to another, it changes its direction and this is light refraction.

- Refracted light rays could be parallel if the refracting surface is smooth, and could be converged or diverged if the surface is curved.

- Variable thicknesses of lenses determine the point at which the light rays do converge, the thicker the lens the greater is its refractory power and the closer is the point of convergence.

- Main refraction in the eyes occurs in the "Cornea". *when light comes from "far source" the light would be already "parallel" and easy to converge, while light from a "close source" would be still diverging from the source, so it needs greater refraction in order to straighten up and be parallel and refracted once again to converge at a more "distant" point relatively.

- To have light from a close source refracted and converged to same point of that of distant site, we need more refractive power which is achieved by "increasing lens convexity".

- Lens is translucent and elastic, being able to change its convexity via the ciliary muscles.

- For good picture formation: we need lens accommodation for near objects via increasing its convexity, pupil constriction to increase visual depth, and bilateral convergence of the eyes.

- **Ametropia**: inability of properly focusing light on retina, mainly due "size" problem of the eye,i.e.: eye being larger or smaller than its supposed normal size. in case of "large eye size": no matter how the lens "reduces its convexity and becoming flat", light converges "before the retina", this occurs in "nearsighted (myopic) eye" while in case of "small eye size", no matter how the lens "increases its convexity", light converges "beyond the retina" and this occurs in "farsighted (hyperopic) eye".

- In the second case, the eye is smaller in size. No matter how much the lens tries to make itself round, the light would be refracted farther away. This is called hypersightedness or farsightedness.

- For the first case, we prescribe a concave lens to distract the light rays. In the second case, we give a convex lens to gather the light.

- Visual acuity: our ability to differentiate between two points and see them as two separate points. Our visual acuity is about 2 mm at 6 m distance.

- According to our retina, and the distribution of photoreceptors, the refraction will determine that this one point is one point and make it look the way it really does, not larger. If, when the light hits the retina, the light has not fully converged, we would see the point as being larger than it really is. Instead of seeing it as 0.1 mm in diameter, we would see it as 0.5 mm in diameter. If the convergence does not happen on the retina, this does not mean that you are not going to see the point; it only means that you are going to see a distorted image of that point.

- **Eye examination:**
    - If we have a refraction problem, this will decrease the visual acuity. The eye charts depend on the concept of visual acuity. At a distance of 6 meters, you are shown a figure with two points at 1.75 mm apart. You are supposed to see them as two separate points; however, if you have problems, you will either see them as one point or not see them at all.
    - On one line of the chart, you either have letters or some sort of a shape missing a part (opening in a certain direction). (points with 1.75 mm in between them)
    - On a different line, you have numbers (either 5's or 4's); they are usually smaller in size. Why is this line important?! The distance between any two points on the chart is smaller than 1.75 mm. This means that these points are distinguishable as two separate points at a distance of five meters. If the person can still distinguish them as two separate points at 6 meters, we call this case super visual acuity or

hyperacuity. It is a normal variation of vision, with a prevalence of 15-20% among the population.

- The larger lines have lines like 9, 18, 36 or other numbers. If you only see the 9, for example, that means that the normal person sees this at 9 meters distance. While you are only able to see it clearly at a distance of 6 meters.

- The patient, when tested, the eyes are tested individually so that one eye's test will not affect the other eye's test.

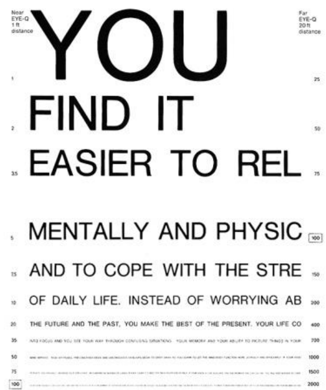
- If the person sees normally, they are said to have 6/6 vision. If they can see the 4, 5, then they have super visual acuity but the number is left as 6/6. If they only can see 9, or 18 or above. That means what a normal person can see at 9 meters, they see at 6 meters. The vision is accordingly rated as 6/9 or 6/18 depending on the distance.

- If a person's vision is 6/18, that does not mean he can see 1/3 of the normal people. It only indicated a degree of weakness. It puts you in frame. If, for example, you are able to see the 9 that does not exclude your ability of seeing the 7, 8, or any other number in between 6 and 9. So you try on lenses, until it works.

- The 0.5, 1, 1.25 degrees written on the lenses refer to the power of the lens to return your vision to normal. Usually, the lens's number is preceded by a negative sign indicating that the lens is concave.

- Farsightedness does not mean that the person sees farther objects better. The person would see the point at 6 meters as a normal person would do, but they do not have super visual acuity. What is different is that they cannot see nearby objects. This is due to a weakness in the accommodation. To test for farsightedness, we use a different chart. This chart is a small chart the size of the palm of the hand. It has different phrases written in different sizes. The patient is asked to hold the chart away from their face. Then, they are asked to bring the chart closer to their face. Once they cannot read what is written on the paper, the doctor can diagnose the degree of farsightedness according to a preset value.

Farsightedness eye chart

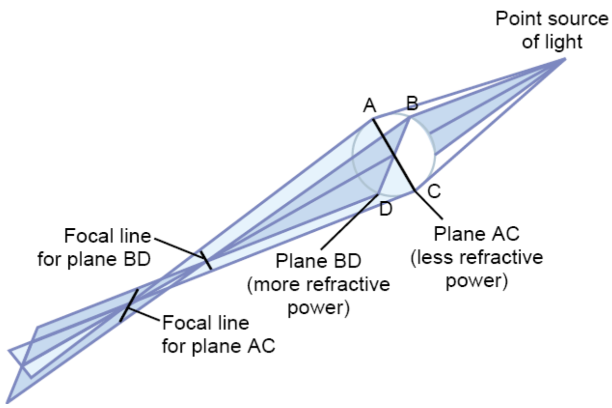


- The lens' ability to bend is largely due to its elasticity; with age, this elasticity decreases. This is called presbyopia. People might lose the lens' elasticity due to old age, but muscular and neuronal injuries of the eye can cause this, as well. The loss of the elasticity causes the lens to lose its accommodation power. This will not only cause farsightedness; it will cause nearsightedness, as well. The patient, in this case, will wear two different glasses.

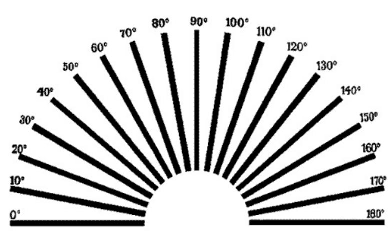
- **<u>Astigmatism</u>**:

  - It is a condition that occurs when the cornea - which contains a curvature, is supposed to refract the light and is round shaped- becomes irregularly rounded (i.e. when we have an inflated ball it's rounded but when we start deflating it, it loses its roundness and we start to notice some bumps all over it) so in this case the refraction won't be equal in the cornea and the light from one area will be refracted more than that from another, so part of the light that falls on the eye will be on the retina while the other won't, and no matter how much the lens tries to accommodate it will not be able to gather the light in one spot on the retina; when it accommodates to fix the first part that's not falling on the retina it will change the position of the other part because we don't have regular refraction, so eventually it will accommodate on the majority of the light that's entering the eye.

- As in the case below part of the light refracts on one point while the other refracts on another point and no matter who much the lens tries to accommodate it will fail and accommodate to majority of light eventually and we'll still have a ray out of focus, and out of focus doesn't mean that it's not there or that the patient can't see it, it simply means that it is seen as wider at that moment.

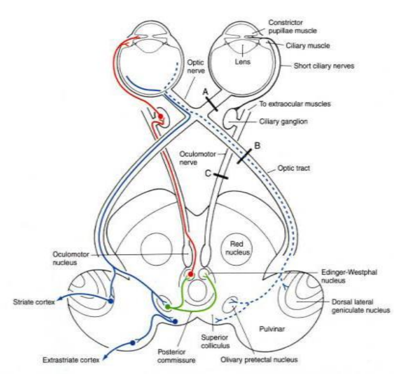


- The best way to test for astigmatism is to have lines in every angle and we ask which line do you see lighter or darker/ longer or shorter than the rest.



- The irregularity can be caused by trauma, due to a defect in the development of the cornea or anything.

- **Papillary light reflex**
  - We have already taken it, light directed towards the pupil will cause constriction to both pupils.



- Loss of optic nerve (A) on the right and shining on the right eye will not cause constriction in any eye, while shining on the left will cause constriction in both (occulomotor is working).

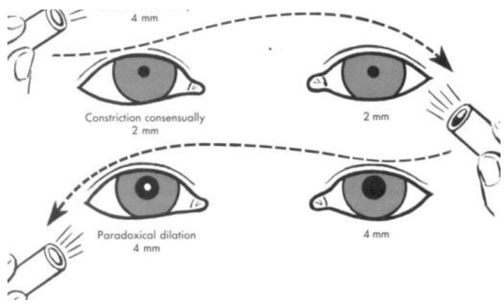
- Loss of (C) on the right: shining on the left; constriction only on the left only. Shining on the right; left only will constrict.

- Loss of (B) on the right: shining on the right will cause constriction on both eyes. Shining on the left will also cause constriction on both eyes.

- The defect that will occur will be in the strength of constriction, because 57% of the fibers will decussate while 43% won't, so shining on one eye will cause more constriction than the other, i.e. on one eye almost 40% is not working and 60% is meanwhile in the other eye 60% is working and 40% isn't, so difference in the strength of the constriction will be observed, notice that both eyes will constrict at the same strength at the same time the difference is in the reaction of both eyes to shining of the light on different eyes; i.e. when we direct the light on the right eye both will be constricted to the same extent but when we direct the light on the left we can notice some dilatation in both eyes equally (this is just an example to explain what happens exactly and doesn't have to apply to the diagram above), and this can't be detected unless we do*; Swinging flash light test* ; when we change shining from one eye to the other we will notice some dilatation meanwhile normally even while swinging both will be constricted to the same degree, this case is called **Relative afferent papillary defect (RAPD)** when we shine on the eye that has 60% of the fibers working we will have constriction by 60% of the normal meanwhile we shine the other eye that is supplied by 40% we will have constriction by 40% of the normal on both eyes.

- RAPD is usually due to a lesion that is uneven on both sides causing the light reflex to be unequal on both sides, the most common reasons behind it are; prechiasm problems e.g. retinal detachment on one eye, ischemic retina, optic nerve neuritis, recurrent neuritis, compression, demyalination or unequal pathology such as glaucoma causing unequal defects on both sides. Other reasons may be unilateral optic tract lesion or mid brain lesion but these are less common.

- We said accommodation happens by parasympathetic against light.



- **Constriction:**
  - Why does this happen?
    - Even with the dimmest light where the pupil should be dilated, when we bring an object close in order to see it the pupil will constrict. This is due to something called *focal depth*. We will collect the light as one point (Eye focusing ideally collects all light rays from a point on an object into a corresponding point on the retina.), and this is where we will have an accurate vision. When light passes through the peripherally of the lens it would be only as one point to a minimal distance (ex 1mm) while when the light passes in the middle of the lens still as one point the distance will be 3mm and this why they say the LENS HAS A BETTER FOCAL DEPTH. This means the 3mm are still emitting the focus this means everything is in focus.

    - This is better for the reading, when your reading a book and you fold the page you see the whole line in focus because behind the constriction of the pupil we have a better focal depth in which everything is in focus unlike if it passed through the peripherally of the lens not everything will be in focus. If you want to see a close object you don't want to just see the surface of the object and anything beyond 1mm out of focus that's why your eye constricts helping you seeing multiple things in focus at the same time. This is done by the parasympathetic, but the order comes directly from the cortex (from association or the secondary but association more usually) to midbrain that I want to see everything in focus so constriction occurs regardless of the light.

- We have 2 mechanisms for constriction (these have a final common pathway through the oculomotor nerve). If one of them stopped working and the other still works we would have a condition called *light near dissociation*. In some cases in patients you would find that you cant induce constriction by light but you can induce by a near object this happens in *Adie's tonic pupil*. It is caused by degeneration to the postganglionic parasympathetic fibers of the ciliary ganglion.

- It's argued that the second track coming there is no postganglionic or when regeneration occurs its induced by cortex.

- Other causes would be any injury to the posterior part of the midbrain (tectal area) around the cerebral aqueduct but preserve EW nucleus could be :
    1) Stoke
    2) Meningitis
    3) Tumor
    4) nuerosphylis
    5) Diabetic neuropathy
    6) Demyelination

- All cases lead to near light dissociation in which we lose the light reflex but we preserve the accommodation reflex. If there is an injury to the pineal gland like a tumor for example, this would enable the person to move his/her eyes up or down its called Parinaud's Syndrome (dorsal midbrain syndrome).

- **Anisocoria**

- Where is one pupil dilated more than the other. We have three different types:
  1) In the light its normal but in the dark one shows more than the other
  2) The other one shows in the light but in the dark
  3) Both in light and dark one pupil bigger than the other

- In light near dissociation the defect was in the *sensory part*, here the defect in the *motor part*. If the parasympathetic fibers were the ones injured then it would be activated by sympathetic, so the pupil would dilate. While if the sympathetic was the one injured, then parasympathetic would take its place and the pupil will be constricted. One of the major causes is Horners syndrome, also one side dorsal midbrain injury here the parasympathetic is injured keep in mind if bilateral leson to the dorsal midbrain (Parinaud's syndrome) this will be light-near dissociation. Also in Adie's tonic syndrome there will anisocroia in the affected eye.

- The same idea occurs in Adie's tonic pupil pupil which will cause anisocoria in the damaged eye.

- As for the normal type during darkness, one pupil will be wider than the other because about twenty percent of the population has physiological anisocoria without any disease or damage to the visual pathway. These individuals will always have pupils of different diameters despite the level of illumination around them.

- **Photoreceptors:**

  - The rods are excited by all colors but are not able to distinguish between these different colors.
  - As for the cones, there are three types; low (blue), medium (green) and high (red), and each of which is activated by a specific wavelength of light. Each wavelength excites these different receptors in different percentages.
  - Examples: light with a wavelength of 450 will excite the low/blue receptors with a percentage of 100, the middle/ green receptors with a

percentage of zero and the high/red with a percentage of zero. As the cortex receives this signal (denoted as [100, 0, 0]), it will understand that the object reflecting this light at this specific wavelength is blue in color. This interpretation depends on previous experiences and visual memories.

  - Another wavelength might excites receptors in these percentages (35, 75, 35) and is perceived as green by the cortex.
  - This mechanism is the basis by which we can differentiate between all the colors we see and that's why we are said to see using our visual cortex, not using our eyes.

  - There are some differences in color perception between males and females. Females are believed to see more shades of colors (i.e. males usually perceive a group of similar colors as one color while females are able to distinguish between these colors). This is because visual processing at the cortex level is different between females and males.

- **Color blindness:**
  - Types of color blindness (according to genetic location):
    - X-linked:This is usually associated with the green and red colors.
      - Types:
        - Deuteranope is when the middle/green frequency is not present.
        - Protanope is when the high/red frequency is not present.
    - Defect in chromosome 7:
      - Chromosome 7 contains the gens that codes for the low/blue frequency receptor.
      - Certain mutations in this chromosome can cause tritanopia which is loss of the blue receptors.
  - Types of color blindness (according to severity):
    - Anopia denotes complete loss of the receptor function (dueteranope, protanope and tritanopia).
    - Anomaly: a mutation that changes the protein shape and shifts the wavelength that maximally stimulates the receptor. The receptor's function is impaired but not completely lost (deuteranomaly, protanomaly or tritanomaly).

- The doctor showed two cubes (slide 47) and asked which square has a lighter orange color just to demonstrate how a slight shift in the receptor's spectrum can shift the perception of a color.

- What is different about these individuals' vision?
  - People who have deuteranope/ deuteranomaly will see trees as green just like normal individuals. Those who have deutranomaly will not even be able to tell that they are color-blind until they are examined by a physician. This is due to the fact that we perceive colors using our cortex, not our eyes.
  - Normal individuals see the color green when they receive a stimulus of (31, 67, 36). If the same color is to be seen by a color-blind individual with deuteranope (missing green receptors), the color will cause the stimulus (31, 36). This is still seen as green because this combination will always be interpreted as an input for green. This does not occur because the cortex compensated for the deficit in green color. It is merely because the individual was taught since childhood that any signal that excites photoreceptors in the percentages (31, 36) is called green.
  - However, the problem arises when these patients want to distinguish between orange and yellow or between green and blue as each pair of these colors have similar signals.
  - These patients, as any other normal individual, see using the cortex. This will enable them to recognize these colors in normal life based on the visual memories they already compiled earlier in their lives. For example, when this person sees an orange, he will notice its shape and see it as orange because this is what makes sense to his cortex.

  - However, if the two colors are shown in the same picture, color-blind individuals will not be able to differentiate between the two colors (orange/yellow or green/blue). So the way to examine these patients is by showing them the chart on slide 50 in which the two colors are present. Normal people will see the number 74, while color-blind individuals will see the number 21 because they wont be able to see the colors in the additional segments that make the number 74. (The extra segment in the number '4' is colored with bright green and it won’t be distinguished by color-blind individuals from the blue-colored area that constitutes the number ‘1’).

- The prevelance of deuteranomaly (green anaomaly) in Jordan is 4% (mostly in males because it is X-linked).

- As for the chart on page 51, it is used to distinguish between deuteranomaly and protanomaly. Normal individuals see the number 42, those with deuteranomaly see the number 4 and those with protanomaly see the number 2.

- **Note:** If all your life someone told you that the color red was yellow, then you will believe all your life that red is yellow.

- **Note:** we actually see with our brain not with our eyes. We perceive colors in our brain.

- **Note:** some people see only black and white (not colors); this happens in cases of absence of cons (they only have rods), or if the part of the cortex responsible for color perception is damaged.

- **Note:** we said that most people with color blindness don’t realize that they’re color blind. However, people with color blindness, after they realize that they actually have color blindness, they start seeing green things white! (this shows how twisted the mind is).

- **Ear Examination:**
  - We said that the sound waves will be converted to vibrations and then to movement of the basilar membrane, after that impulses will be conducted to the brain.

- **Sound conduction can occur through:**

1) Air Conduction: this occurs normally. Here the sound waves will pass through the middle ear, where they will be amplified.
2) Bone Conduction: in this case, the vibrations from the bone will be passed directly to the cochlea without passing through the middle ear so they will not be amplified.

- Note: air conduction is normally better than bone conduction.

- **Types of deafness:**
  1) Conductive deafness:
     - Sounds waves will not pass from the air to the organ of corti.
     - Vibrations can still reach the cochlea through the bone.
     - This can be seen in cases of damage to the tympanic membrane, defects of the middle ear bones (Eg. Calcification), or inflammation in the external auditory meatus.

  2) Sensorineural deafness:
     - Vibration will reach the organ of corti, but the hair cells are either absent, or the auditory pathway is defective.

➢ **Weber's Test:**

- Goal: to differentiate between conductive and sensorineural deafness.
- Steps:

1) Strike the tuning fork to start its vibration.
2) Place the tuning fork on the forehead or on the top of the head.
3) Normally, you will hear the vibrations in both ears equally.
4) If the patient doesn't hear the vibrations in one ear, then he has sensorineural deafness in that ear.
5) If the patient hears the vibrations louder in one ear, then he has conductive deafness in that ear.

➢ **Rinne's Test:**

- Goal: to determine whether conduction is faster by air or bone.
- Steps:

1) Strike the tuning fork to start its vibration.
2) Place the tuning fork in front of the patient's ear.
3) Once the patient tells you that he can't hear the vibrations anymore, place the tuning fork on his mastoid process. Normally, the patient should not hear the vibrations from the mastoid process. If the patient hears the vibrations, this means that he has conduction deafness.
4) If the patient doesn't hear the vibrations by air conduction or bone conduction, this means that he has sensorineural deafness.