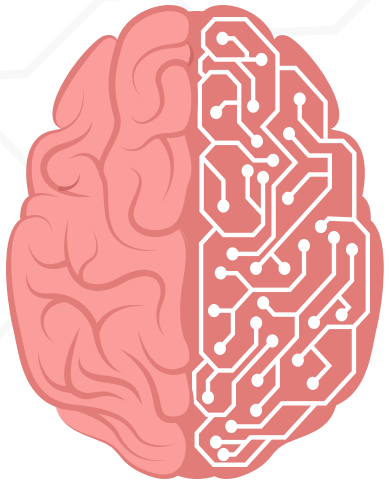


Physiology - CNS

Done By

Islam Bilal

Corrected By

Dana Tarawneh

The Eye: I. Optics of Vision

Faisal I. Mohammed , MD, PhD

We talked before about general sensations that have their receptors in all parts of the body. Now we'll start with special sensations, so grab a cup of coffee and let the fun begin!

Objectives

- Describe the visual receptors
- List the types of lenses and recognize how they work
- Determine the power of lenses **Not about the degree**
- Describe accommodation for near vision and far vision
- Recognize nearsightedness and farsightedness and determine its correction
- Describe visual acuity and its abnormalities
- Determine intraocular pressure and glaucoma

Refractive Index

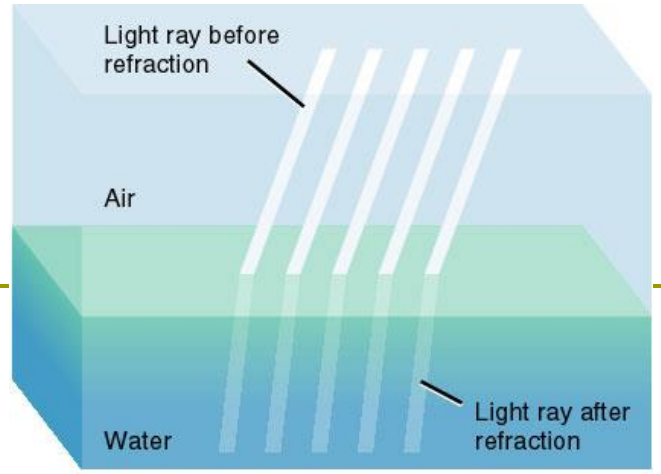
- Speed of light in air 300,000 km/sec.
- Light speed decreases when it passes through a transparent substance.
- The **refractive index** is the ratio of the speed of light in air to the speed of light in the substance.
- e.g., speed of light in substance = 200,000 km/sec, R.I. = 300,000/200,000 = 1.5.

Refraction of Light

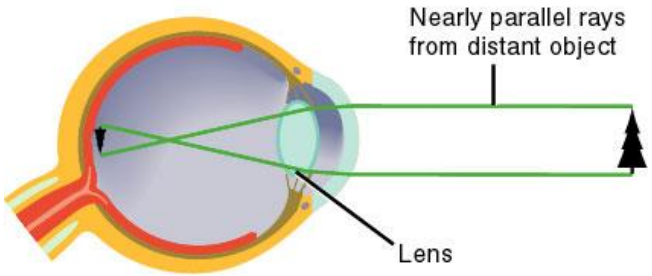
- Bending of light rays by an angulated interface with different refractive indices.
- The degree of refraction increases as the difference in R.I. increases and the degree of angulation increases.
- The features of the eye have different R.I. and cause light rays to bend.
- These light rays are eventually focused on the retina.

Light Refraction

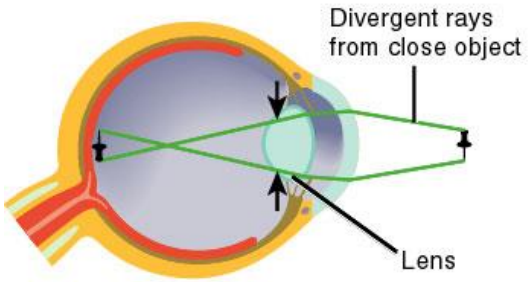
The angle of bending depends on the R.I.
(معامل الانكسار، الله لا يكسر حدا ع قولة الدكتور، لا كسر عظام ولا كسر قلوب :P)
- When we see an object, the light will pass until it reaches the retina where we have our receptors



(a) Refraction of light rays



(b) Viewing distant object



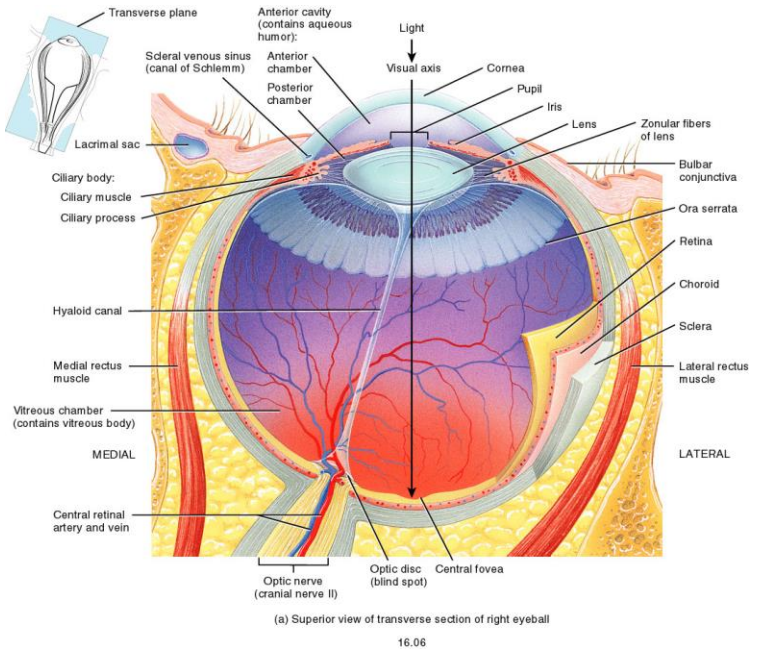
(c) Accommodation

16.11

The doctor made a quick review about the last topic in the previous lec. There is no benefit of repeating it again. Skip the slide 🤝

The doctor repeated the same concepts. I'll write all the extra info. Don't panic!😉

- The cornea takes around 20% of the surrounding eyeball .
- The choroid contains anteriorly the ciliary muscles that continues anteriorly as iris which is the colored part of the eye.
- The iris contains 2 types of muscles
  1. circular muscle that is supplied by parasympathetic fibers from the oculomotor (3rd cranial nerve)
  2. Radial muscle that is supplied by sympathetic fibers .
- The pupil is found in between the iris. (it's the hole at the center of the iris)
- The suspensory ligaments are attached to ciliary muscles, that are inserted with the capsule of the lens.
- The lens is basically a protein fluid-like that transfers the light. 😊 زي البيض الني
- When the capsule is stretched by the suspensory ligament that is attached to ciliary muscles, it becomes less convex, and vice versa (when it is relaxed) .



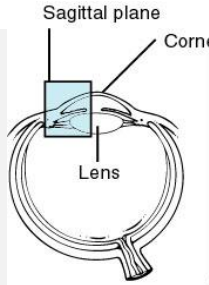
(a) Superior view of transverse section of right eyeball

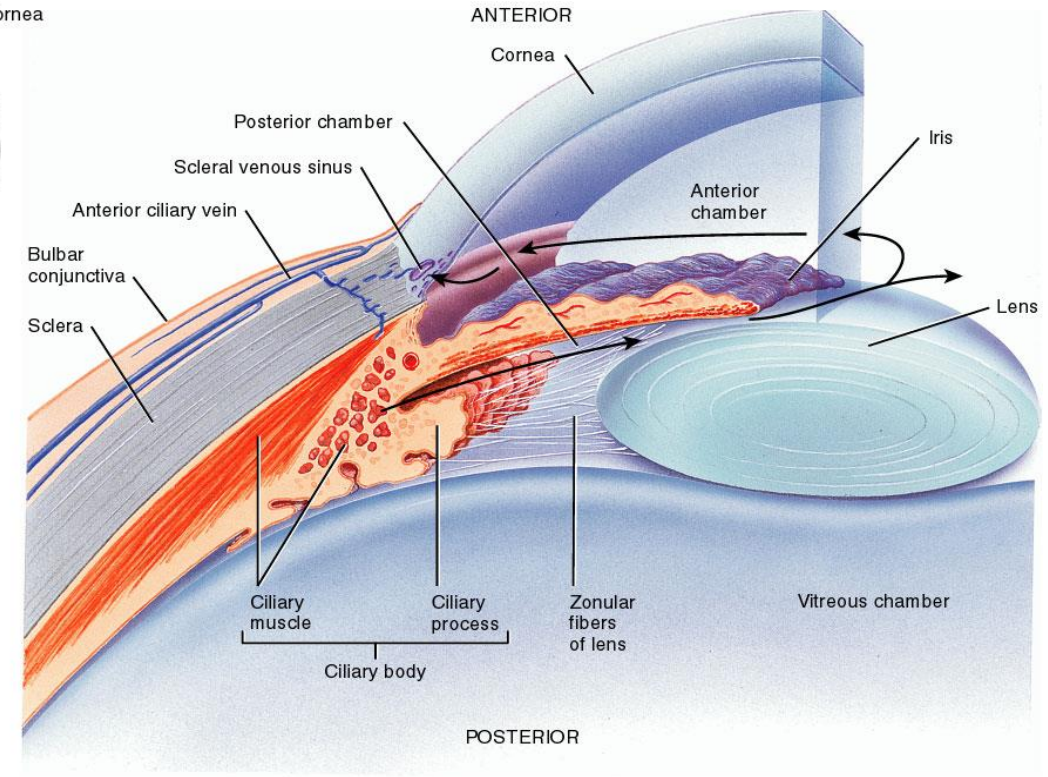
16.06

Cont.

- By age, certain diseases will occur like DM , metabolic diseases for newborns can also occur, which causes denaturation of proteins of the lens (it will become white in color).
- This condition is called cataract (المي البيضا)
- The treatment is changing the lens to a plastic one or something that doesn't have a protein.
- The inner most layer of the eye comes from the ectoderm. It's totally separated from the middle layer. But anteriorly we have 2 chambers that are separated by the lens.
- Anterior chamber: anterior to the iris and lens, and it's filled with aqueous humor سائل زجاجي that formed continuously .
- Posterior chamber: posterior to the iris and lens, it's filled with vitreous humor سائل هلامي .

The aqueous humor is formed in the posterior chamber, then it's reabsorbed in the anterior chamber by the canal
of Schlemm. So, it's quantity is almost constant. And that's way the pressure caused by the humor inside the anterior chamber is fixed (12-20 mm/Hg) , this is called intraocular pressure –IOP-





16.10

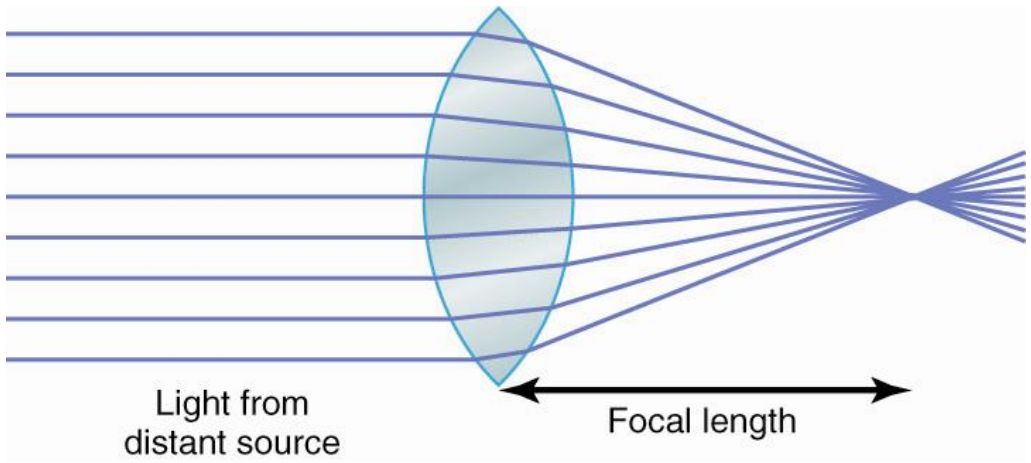
• The main function of aqueous humor is the nutritional support for the cornea, محنا قلنا إنها avascular لحقت تنسى يا معلم 😂
• Sometime due to diseases or age, the canal of Schlemm is blocked (atherosclerosis). The fluid inside the anterior chamber will increase thus the pressure will increase too. So, headache & blindness may happen (glaucoma) المي الزرقا 🤍

CONT..

- The treatment could be done by giving diuretics or operating on the patient (surgery).
- The importance of vitreous humor is protecting the structure of the eye. So, it keeps the retina close to the choroid to maintain its blood supply.
- If there is leakage of the vitreous humor, the retina detaches immediately.
- Imagine that the vitreous humor compresses the retina and keeps it attached to the choroid, any decrease in the humor will cause a decrease in the pressure and thus detachment (retina that has receptors will die so blindness will occur) and this is an emergency for ophthalmology, they should fix it again immediately.
- In our bodies, there are more than one example on organs like the eye. In the adrenal gland we have 2 completely separated layers (medulla -neural- and cortex –glandular-) . Also, in the pituitary gland we have a glandular tissue anteriorly and neural tissue posteriorly.

Refractive Principles of a Lens

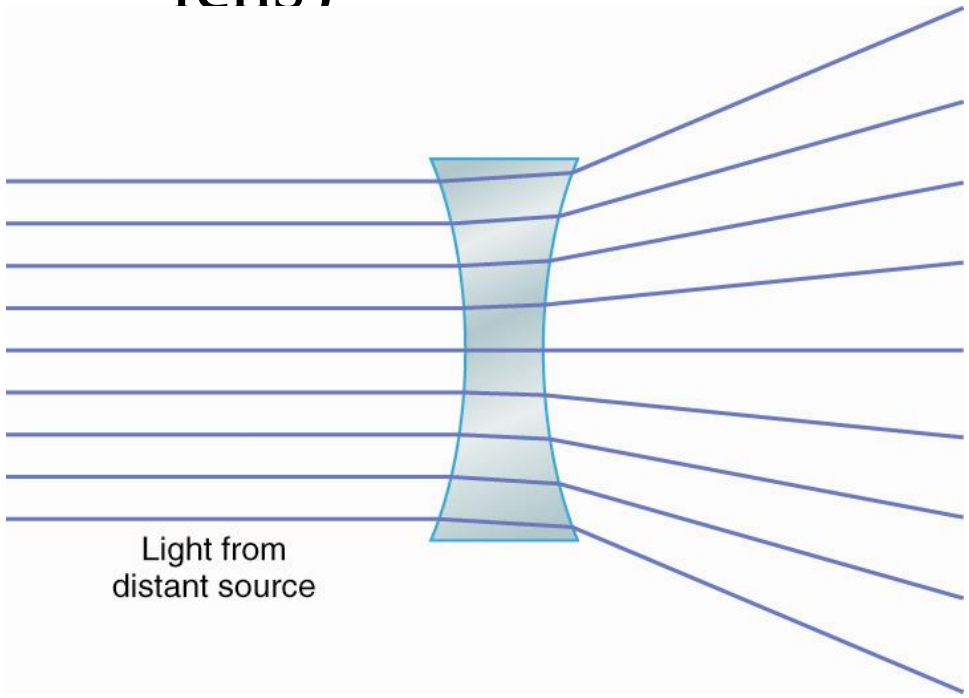
- Convex lens focuses light rays (converging lens)



In Convex lenses (positive lens): The parallel lines will be focused in one point called a focal point.
And the distance between the point and the center of the lens is called focal length.

Refractive Principles of a Lens

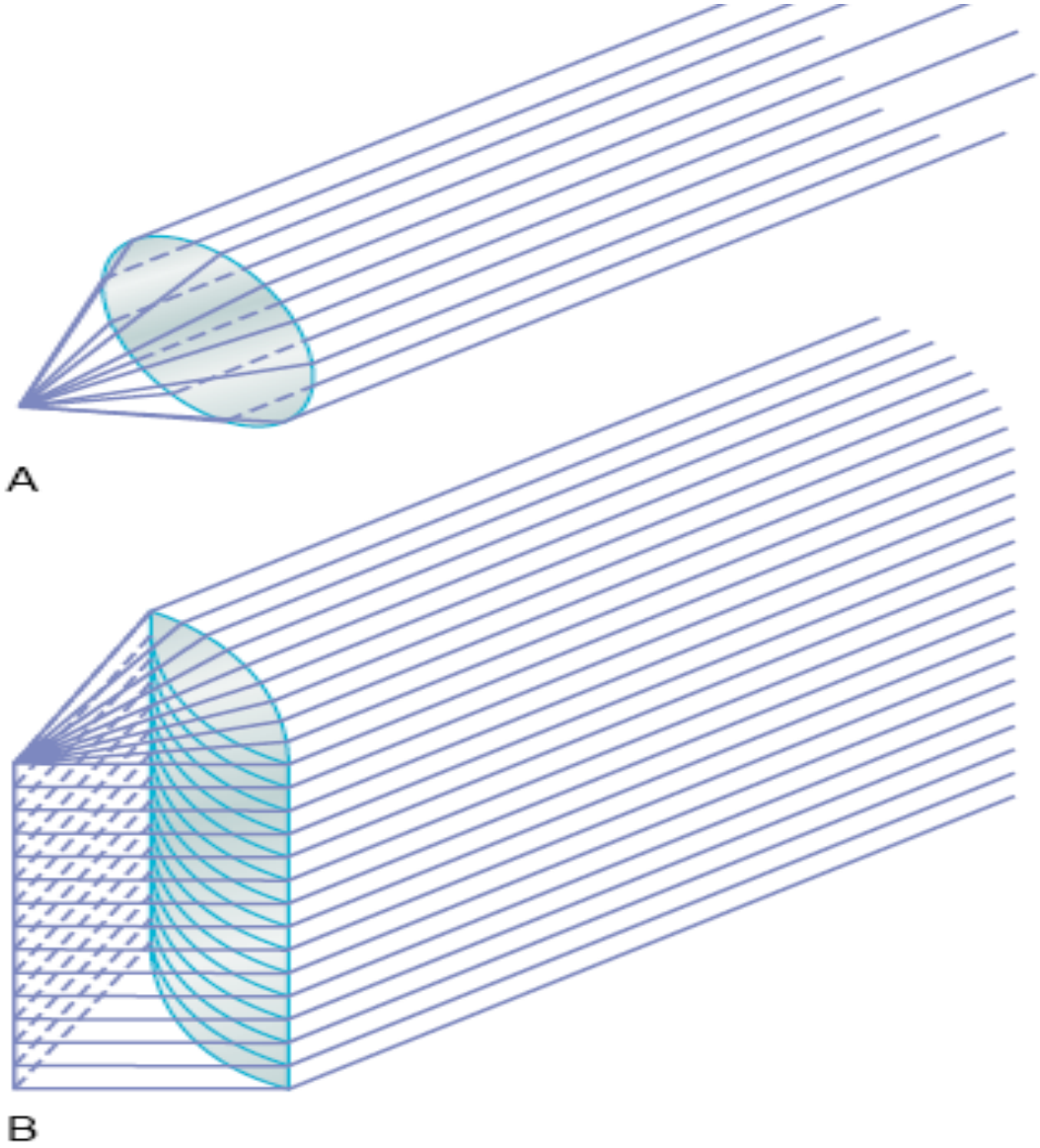
- Concave lens diverges light rays (diverging lens)



The diverging lenses (negative lens): The parallel lines will be diverged unless the line comes from the point in the center of the lens, it will then continue straight.

Spherical Lens

(Focal points)

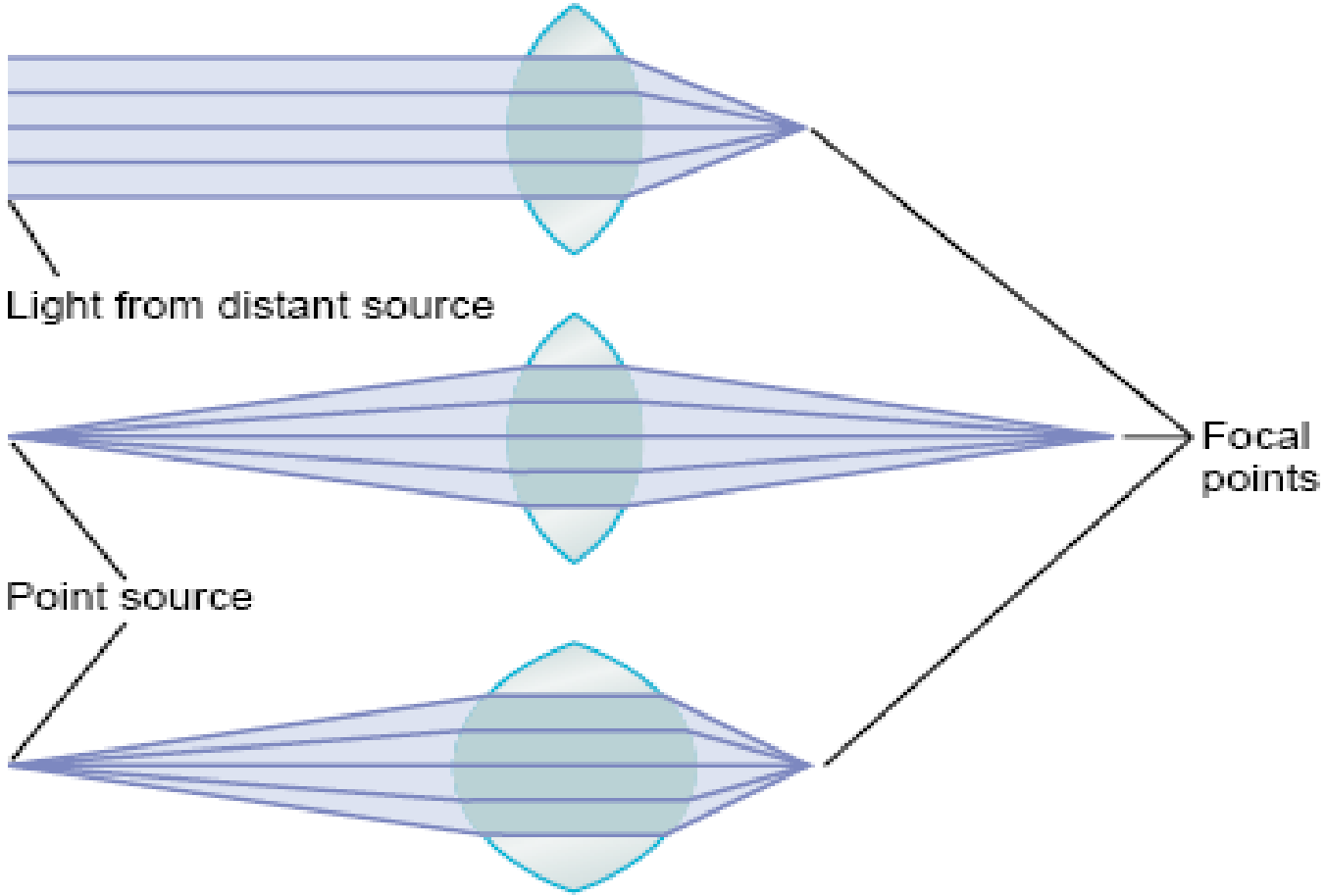


Cylindrical Lens

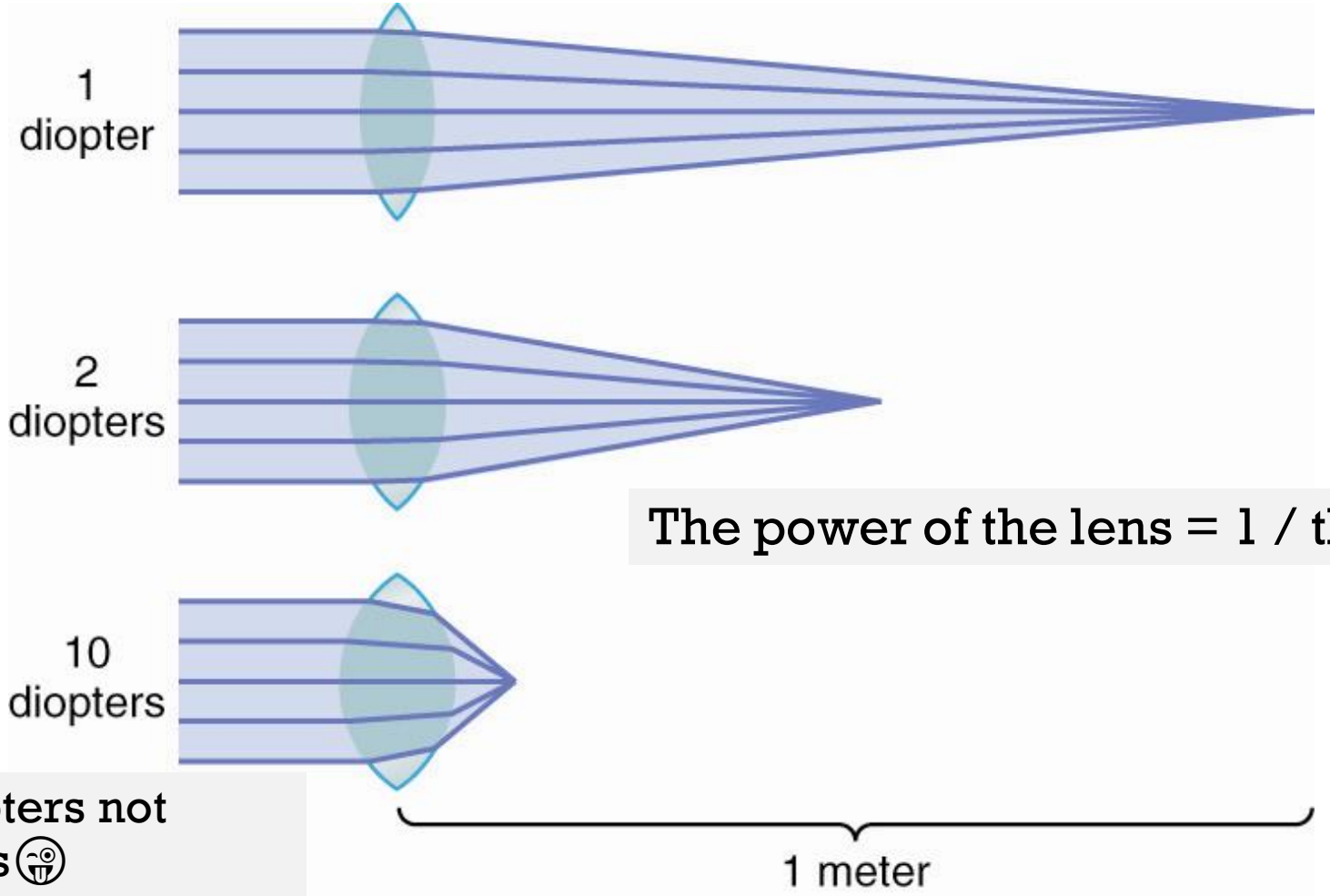
(Focal line)

The focal points make a focal line

If the lens becomes more convex, the focal point will become closer to it.



The Refractive Power of a Lens



The power of the lens = 1 / the focal length in meter

It's diopters not degrees 😜

Figure 49-8; Guyton and Hall

Focusing Power of the Eye

- Most of the refractive power of the eye results from the surface of the cornea.
  - a diopter is a measure of the power of a lens
  - 1 diopter is the ability to focus parallel light rays at a distance of 1 meter, it is a measure of power of lenses
  - Diopter = 1/ focal length in meters i.e the power of a lens with focal length 0.5 meter is 2 (more convex)
  - the retina is considered to be 17 mm behind the refractive center of the eye
  - therefore, the eye has a total refractive power of 59 diopters (1000/17)

Image formation on the retina-requirements

- Light refraction or bending the light by the refractive media – Cornea, Aqueous humor, Lens and Vitreous humor.(In order) Cornea contributes around 42 diopters out of the total of 60 for all media. So, cornea is very important
- Accommodation: An increase in the curvature of the lens for near vision,
  - The near point of vision is the minimum distance from the eye an object can be clearly focused with maximum accommodation
- Constriction (meiosis) and dilation (Mydriasis) of the pupil
- Convergence and divergence of the eyes for binocular vision

*By calculations, if we removed all these media and replaced them with one media, the total R. Power until reaching the retina is 60.
* The lens can change its power, so the younger the age, the more flexible the lens is.
* When we look too far, the ciliary muscles relax, then press on the lens to be less convex with more focal distance and less power and vice versa (when we look at near objects).

Accommodation

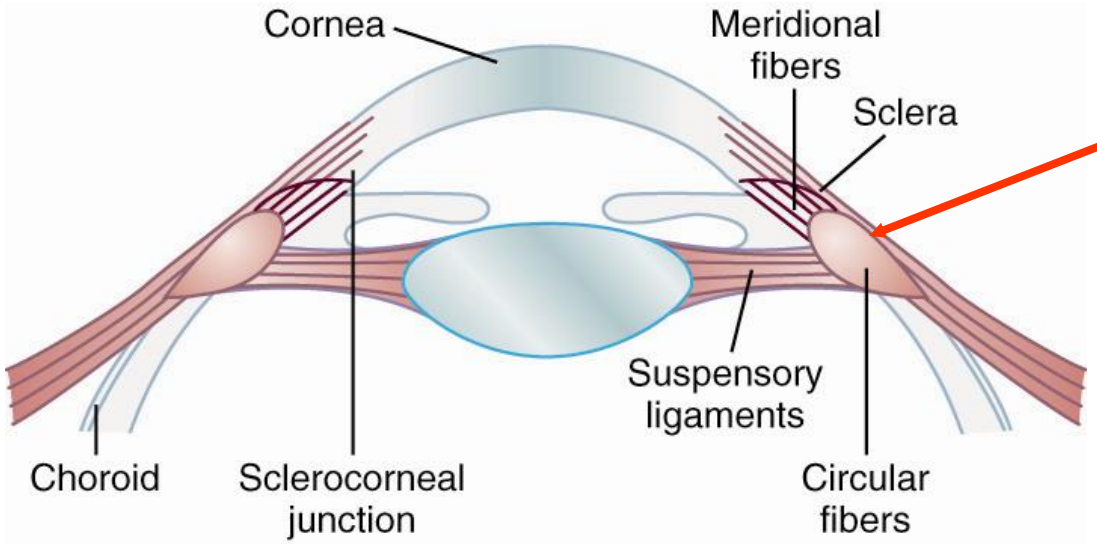
- Refractive power of the lens is 20 diopters.
- Refractive power can be increased to 34 diopters by changing shape of the lens - making it fatter (more convex).
- This is called accommodation.
- Accommodation is necessary to focus the image on the retina.
- Normal image on the retina is upside down.

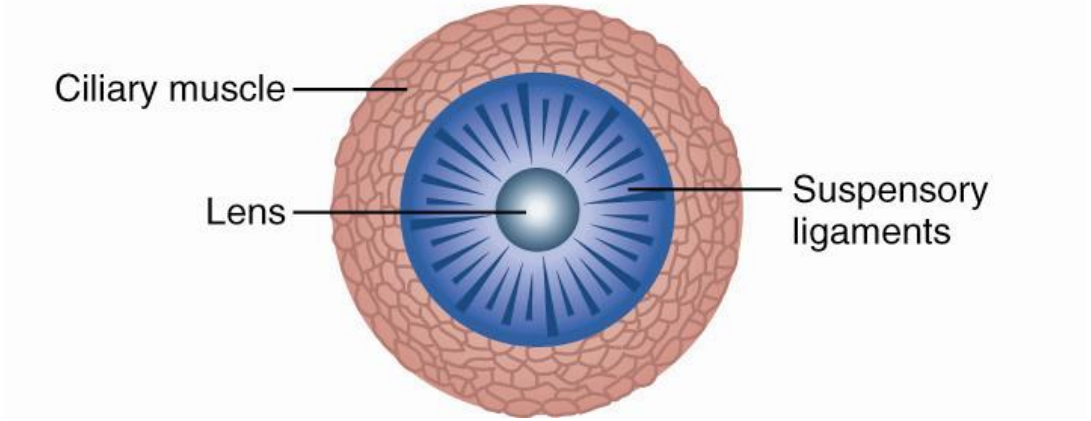
When we see an object, we form an image on the right & left retina, but we see them as one picture by the cortex because they are overlapped on the cortex.
So, they are formed on exactly the same areas on the retina, since they go to the cortex which will overlap them.
Whenever they aren't overlapping, diplopia will happen (مش نفس الحول)

Mechanism of Accommodation

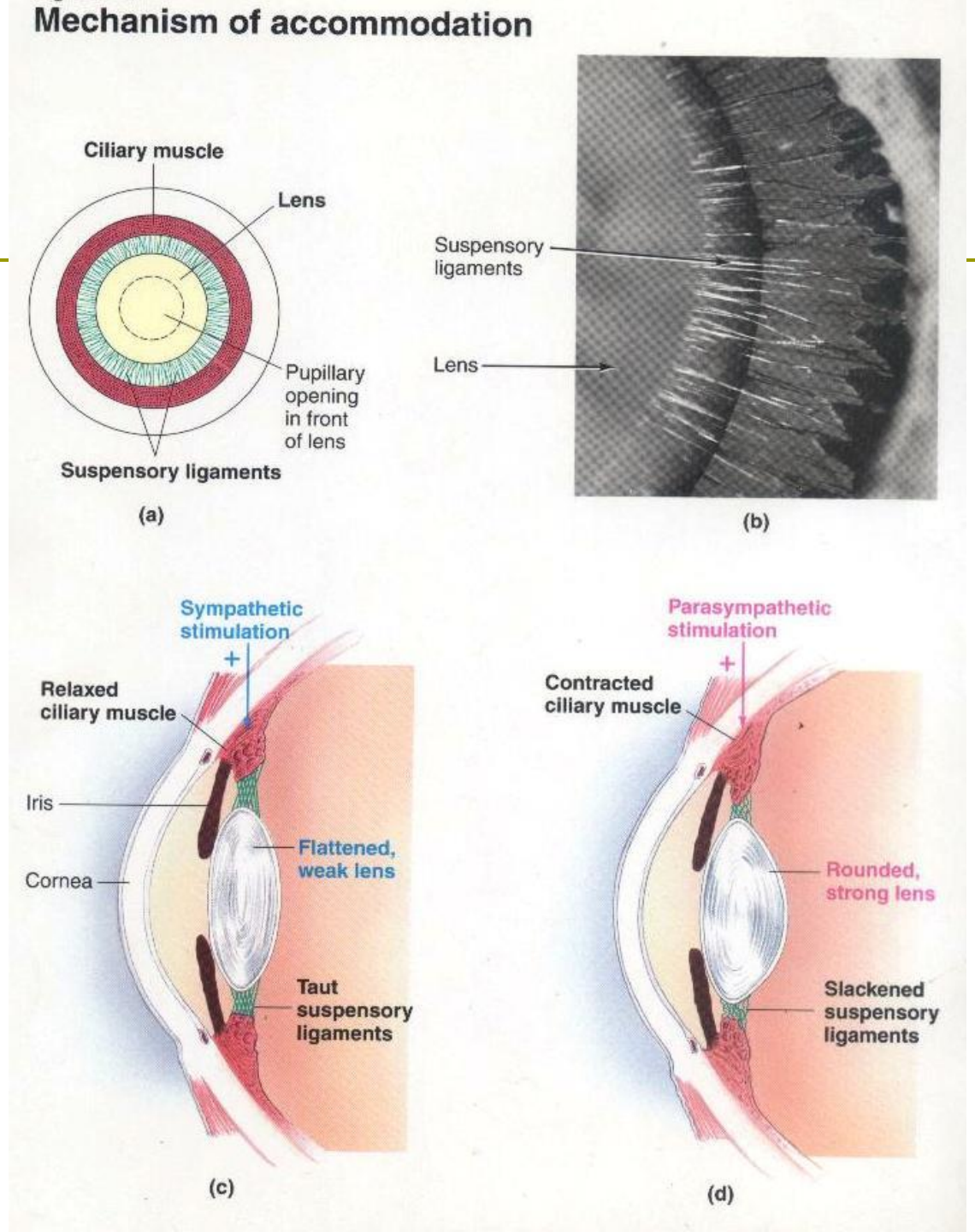
- A relaxed lens is almost spherical in shape.
- Lens is held in place by suspensory ligament which under normal resting conditions causes the lens to be almost flat.
- Contraction of an eye muscle attached to the ligament pulls the ligament forward and causes the lens to become fatter (more convex) which increases the refractive power of the lens.
- Under control of the parasympathetic nervous system.

Mechanism of Accommodation



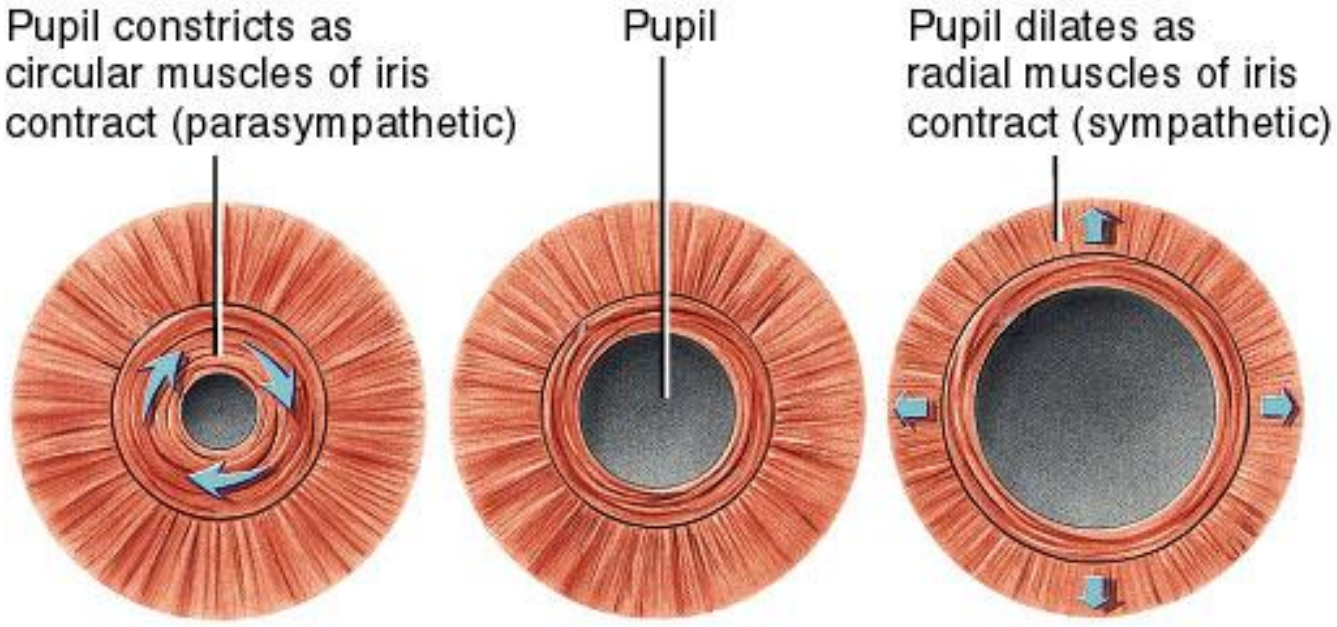


Contraction pulls the ligament forward relaxing tension on suspensory ligament making the lens fatter



Relaxed ciliary muscles, tense suspensory ligament, less convex lens, less power, more focal length.
- For far vision

Contracted ciliary muscles, relaxed suspensory ligament, more convex lens, more power, less focal length
- For near vision



- When we look too far, there's not much light coming in, so the pupil must dilate (contractions of the radial muscles)

- When we look to a near object, there is too much light coming in , so the pupil must constrict (meiosis – parasympathetic from oculomotor)

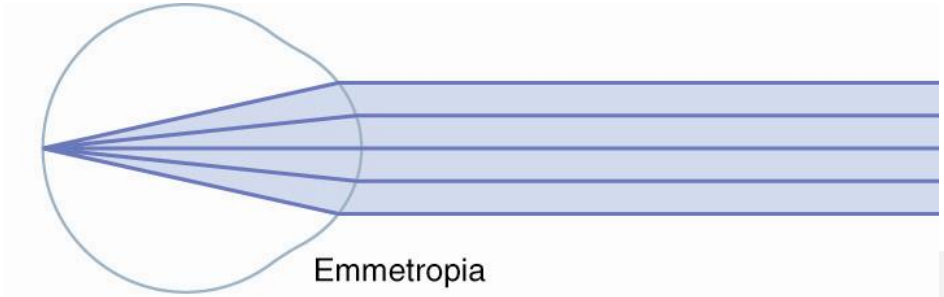
Presbyopia; The Inability to Accommodate

Lazy eye, the lens lost its flexibility

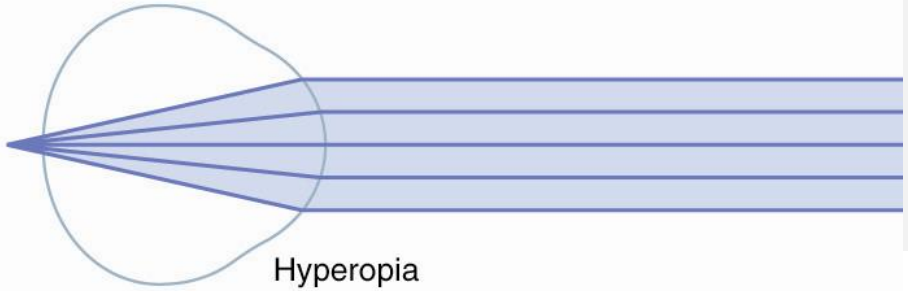
- Caused by progressive denaturation of the proteins of the lens.
- Makes the lens less elastic.
- Begins about 40-50 years of age.

Errors of Refraction

Normal vision

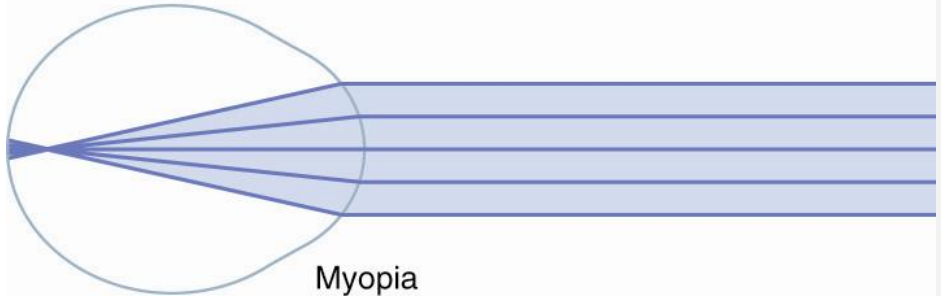


Far sightedness
بعد النظر



The distance between the lens and retina is less than normal, so the image is formed behind the retina. This patient needs spherical positive glasses

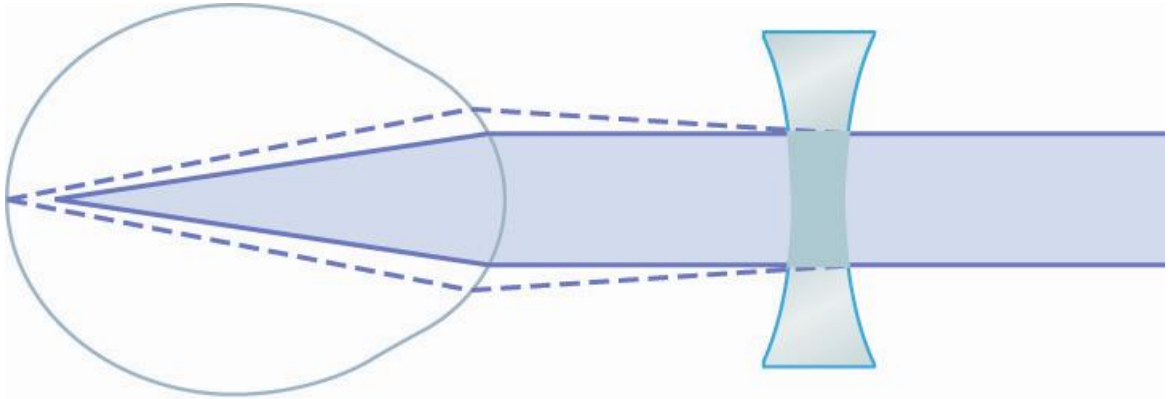
Near sightedness



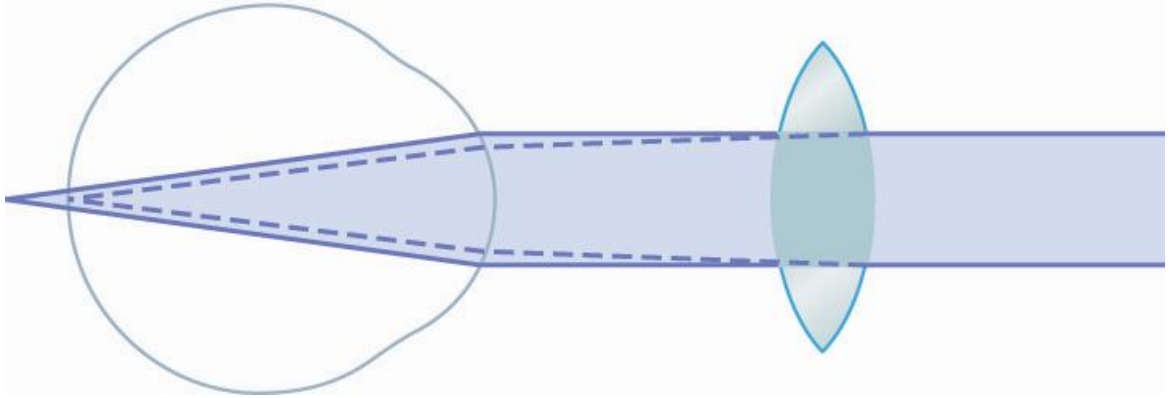
The distance between the lens and retina is more than normal, so the image is formed in front of the retina. We need biconcave lens for these patients

Correction of Vision

Myopia corrected with concave lens

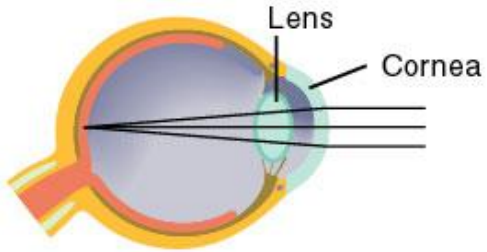


Hyperopia corrected with convex lens

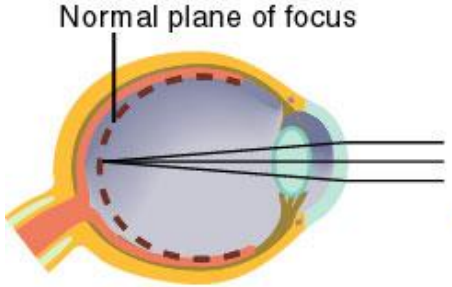


Errors of Refraction

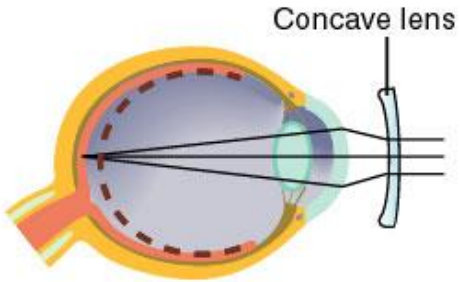
Look at each lens we used



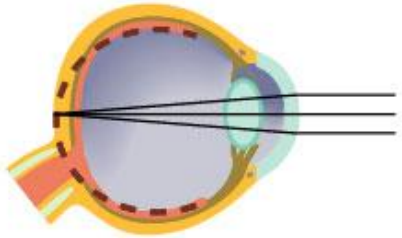
(a) Normal (emmetropic) eye



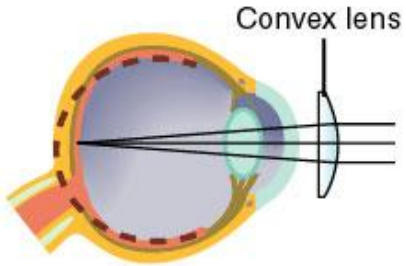
(b) Nearsighted (myopic) eye, uncorrected



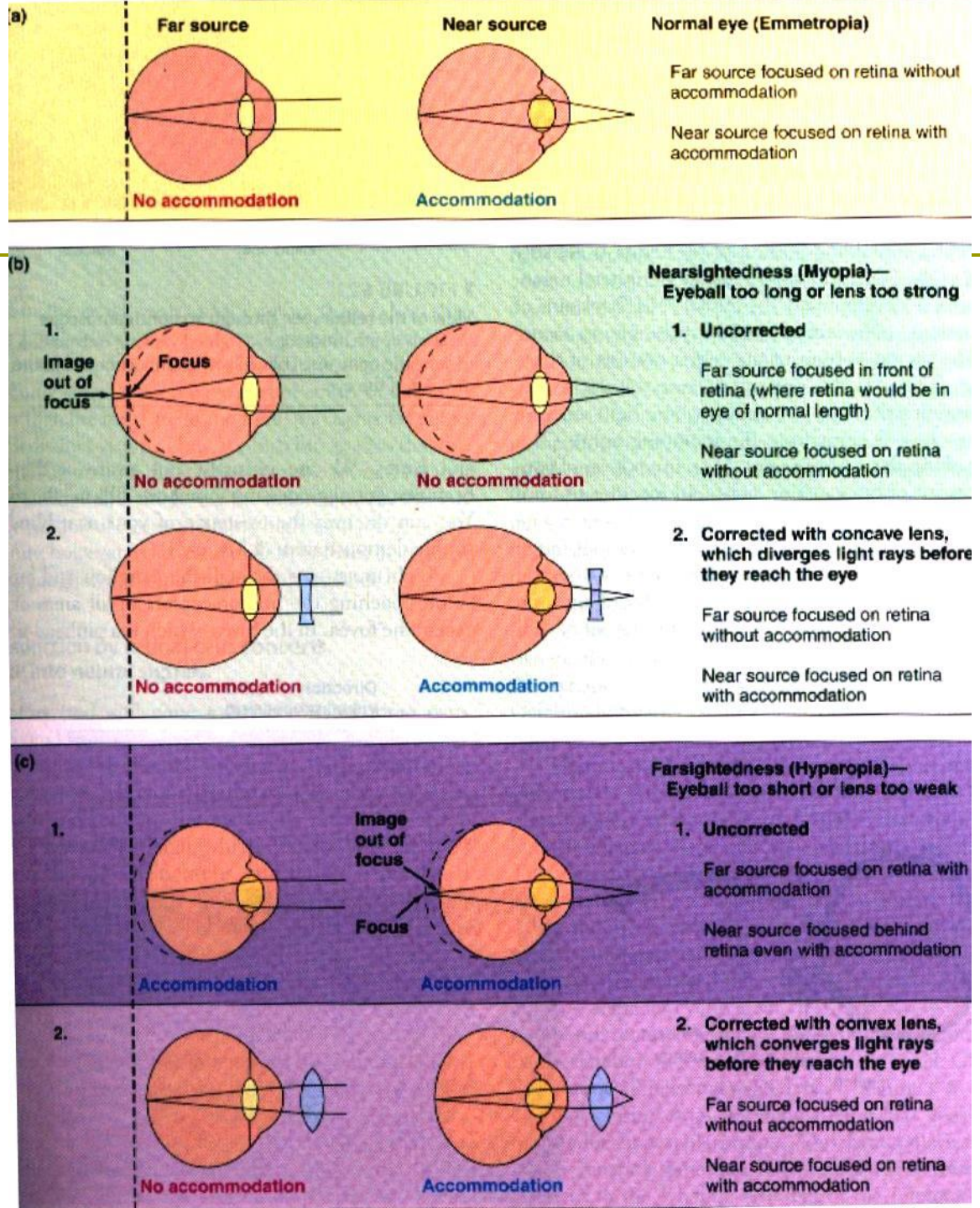
(c) Nearsighted (myopic) eye, corrected



(d) Farsighted (hypermetropic) eye, uncorrected



(e) Farsighted (hypermetropic) eye, corrected


(a)
Far source
Near source
Normal eye (Emmetropia)
Far source focused on retina without accommodation
Near source focused on retina with accommodation
No accommodation
Accommodation
(b)
Nearsightedness (Myopia)—
Eyeball too long or lens too strong
1.
Image out of focus
Focus
1. Uncorrected
Far source focused in front of retina (where retina would be in eye of normal length)
Near source focused on retina without accommodation
No accommodation
No accommodation
2.
2. Corrected with concave lens, which diverges light rays before they reach the eye
Far source focused on retina without accommodation
Near source focused on retina with accommodation
No accommodation
Accommodation
(c)
Farsightedness (Hyperopia)—
Eyeball too short or lens too weak
1.
Image out of focus
Focus
1. Uncorrected
Far source focused on retina with accommodation
Near source focused behind retina even with accommodation
Accommodation
Accommodation
2.
2. Corrected with convex lens, which converges light rays before they reach the eye
Far source focused on retina without accommodation
Near source focused on retina with accommodation
No accommodation
Accommodation

Other Errors of Vision

- Astigmatism
  - unequal focusing of light rays due to an oblong shape of the cornea
- Cataracts — Denaturation of the lens
  - cloudy or opaque area of the lens
  - caused by coagulation of lens proteins

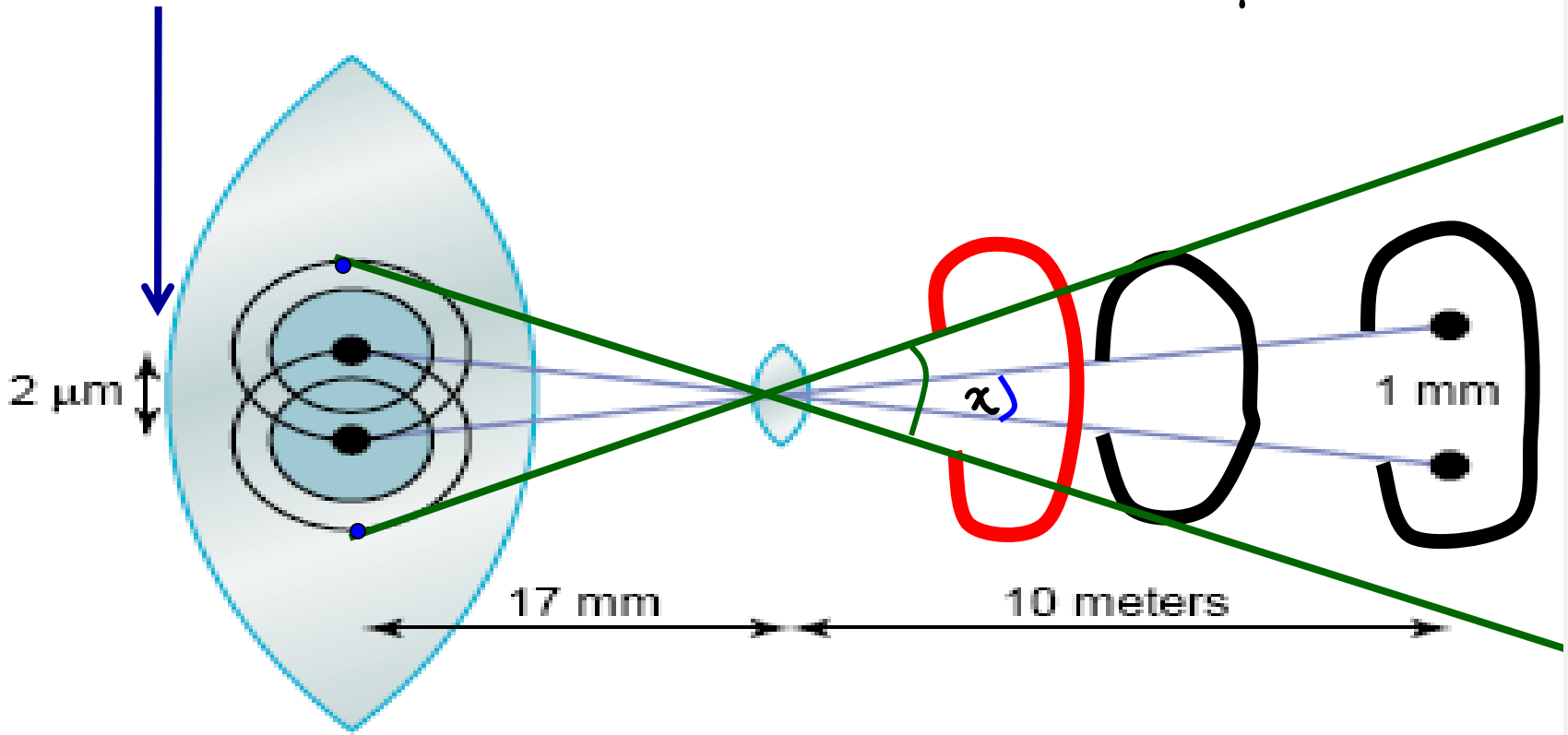
The cornea is a group of cylindrical lenses that have to meet at one point.

If one of them doesn't meet them at the same point, astigmatism will happen.

Here, we must put a new cylindrical lens (glasses) for the patient and correct the damaged one

Visual Acuity Test

The diameter of the cones in the fovea is ~ 1.5 μm

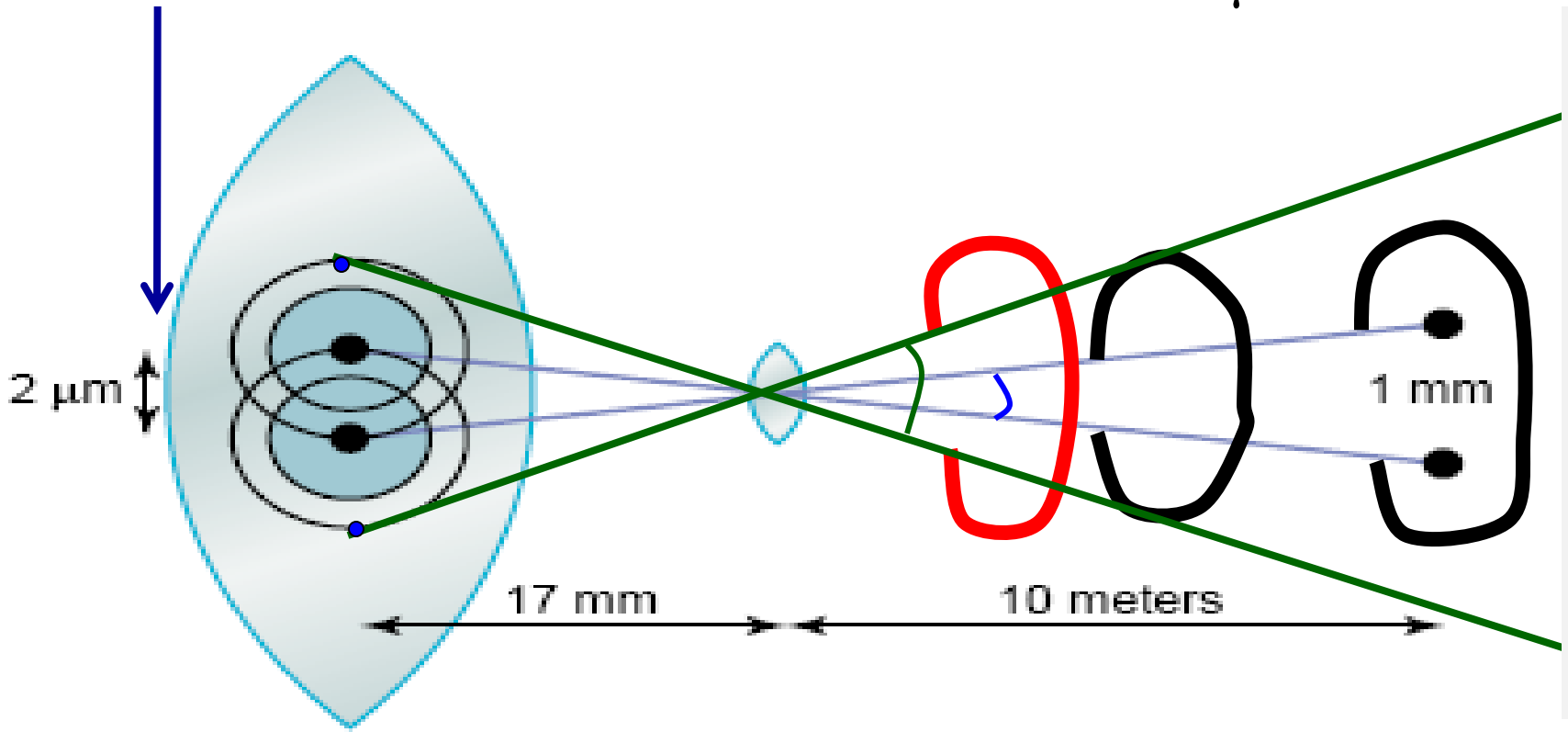


We have 2 types of receptors on the retina: cons and rods.
We deal with cons for acute vision.
To read this black C letter, it has to hit 2 receptors. If it hits one receptor, we will see it as an O.
Using mathematics, the distance between 2 receptors is 2 micro m , and the distance between the lens and retina is 17mm.
The X angle will be almost 1 min (the circle is 360 degree, every degree is 60 min , every min is 60 sec)
So, we draw several Cs with different sizes at these standard numbers, and the one who sees all of them will have 6/6 vision.

Americans deal with feet instead of meters.
1 m= almost 3 feet

Visual Acuity Test

The diameter of the cones in the fovea is ~ 1.5 μm



If a person's vision is normal , he can see the "C" at a distance of 9 meters but if that person's vision is abnormal, you'll have to bring it to a distance of 6 meters so that he can see it clearly (his vision is 6/9)

6 = the abnormal person's vision.
9 = the normal person's vision.

Americans deal with feet instead of meters.
1 m= almost 3 feet

Visual Acuity: depends on the density of receptors (primarily Cones)

- 6/6
  - ability to see letters of a given size at 6 meters
- 6/12
  - what a normal person can see at 12 meters, this person must be at 6 meters to see.
- 6/60
  - what a normal person can see at 60 meters, this person must be at 6 meters to see.


Z S H C
H S K R N
C H K R V D
H O N S D C V
O K H D N R C S
V H D N K U O S R C
B D C L K Z V H S R O A
H K G B C A N O M P V E S R
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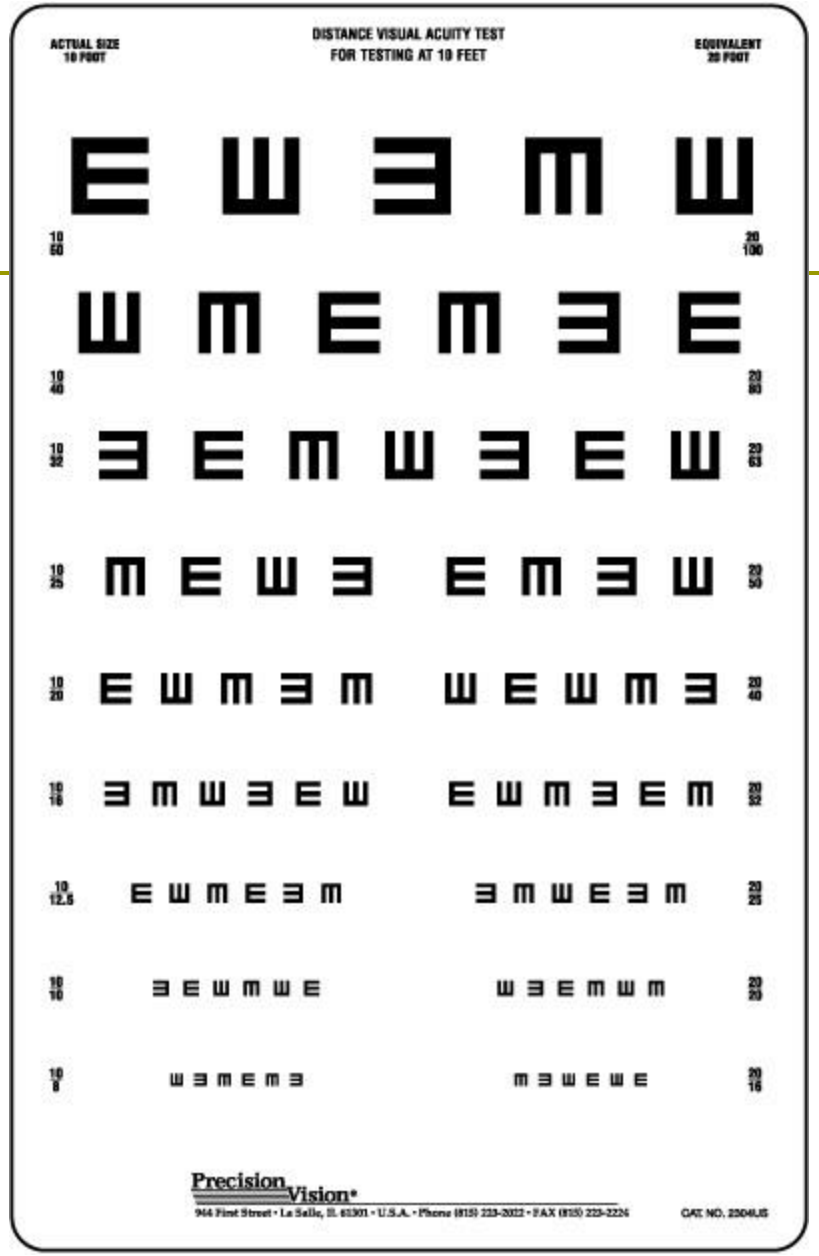
ACTUAL SIZE
10 FOOT
DISTANCE VISUAL ACUITY TEST
FOR TESTING AT 10 FEET
EQUIVALENT
20 FOOT
Precision Vision
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