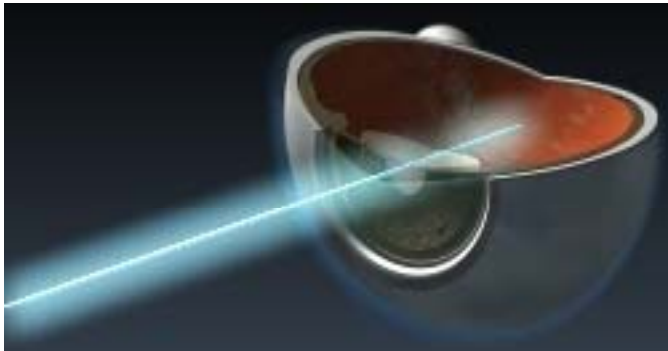
Refractive Errors

by

Hani Al-Mezaine

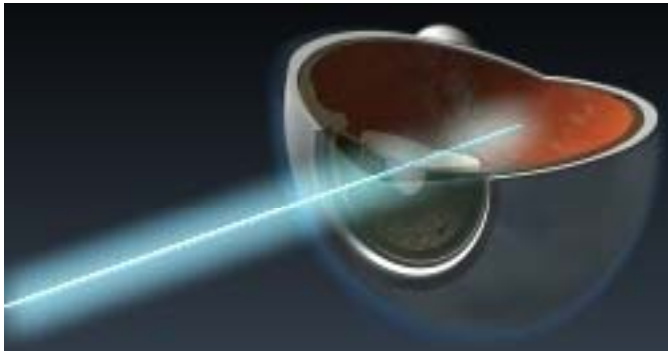


FACTS

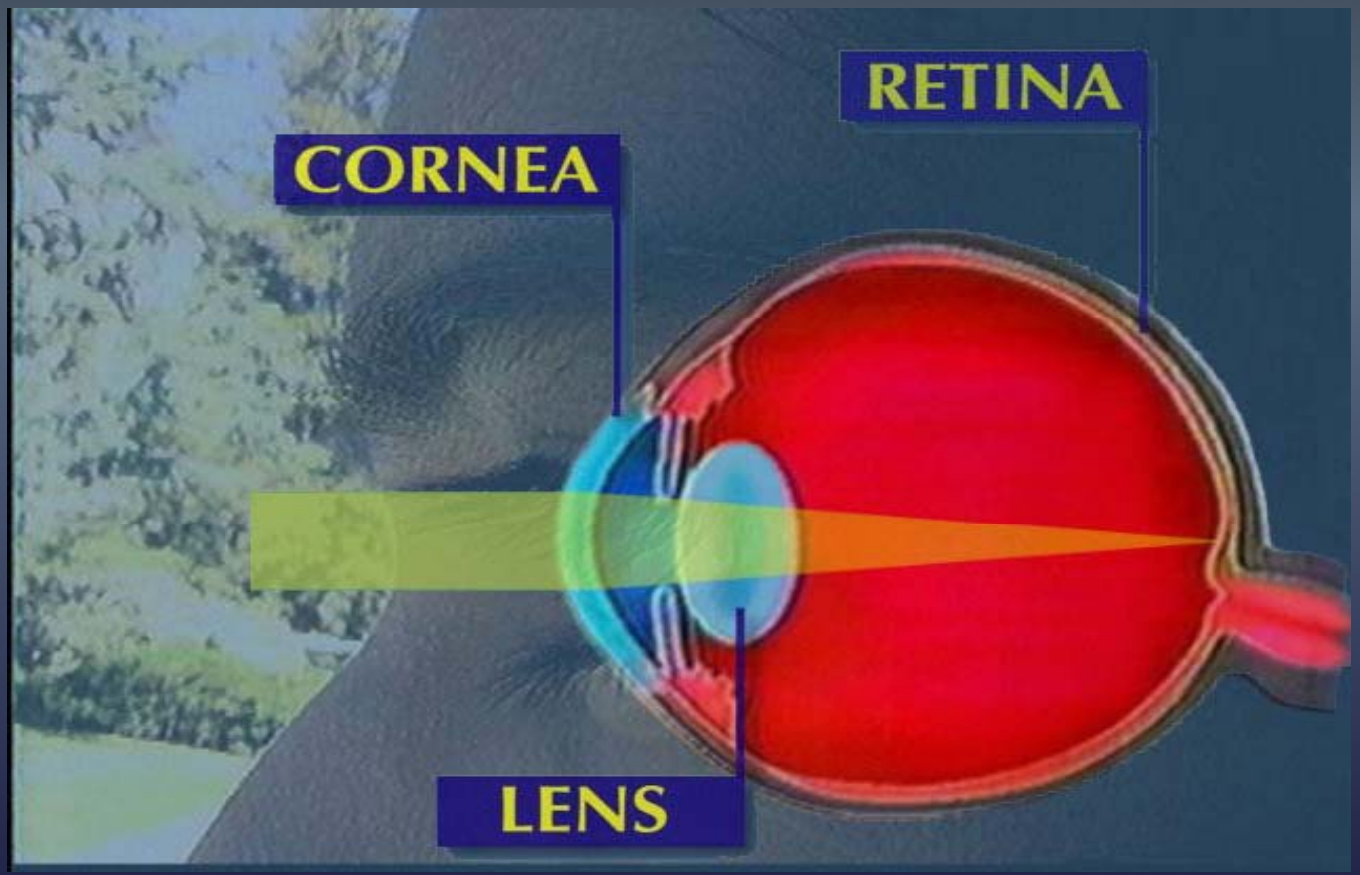
75% of avoidable blindness is due to:

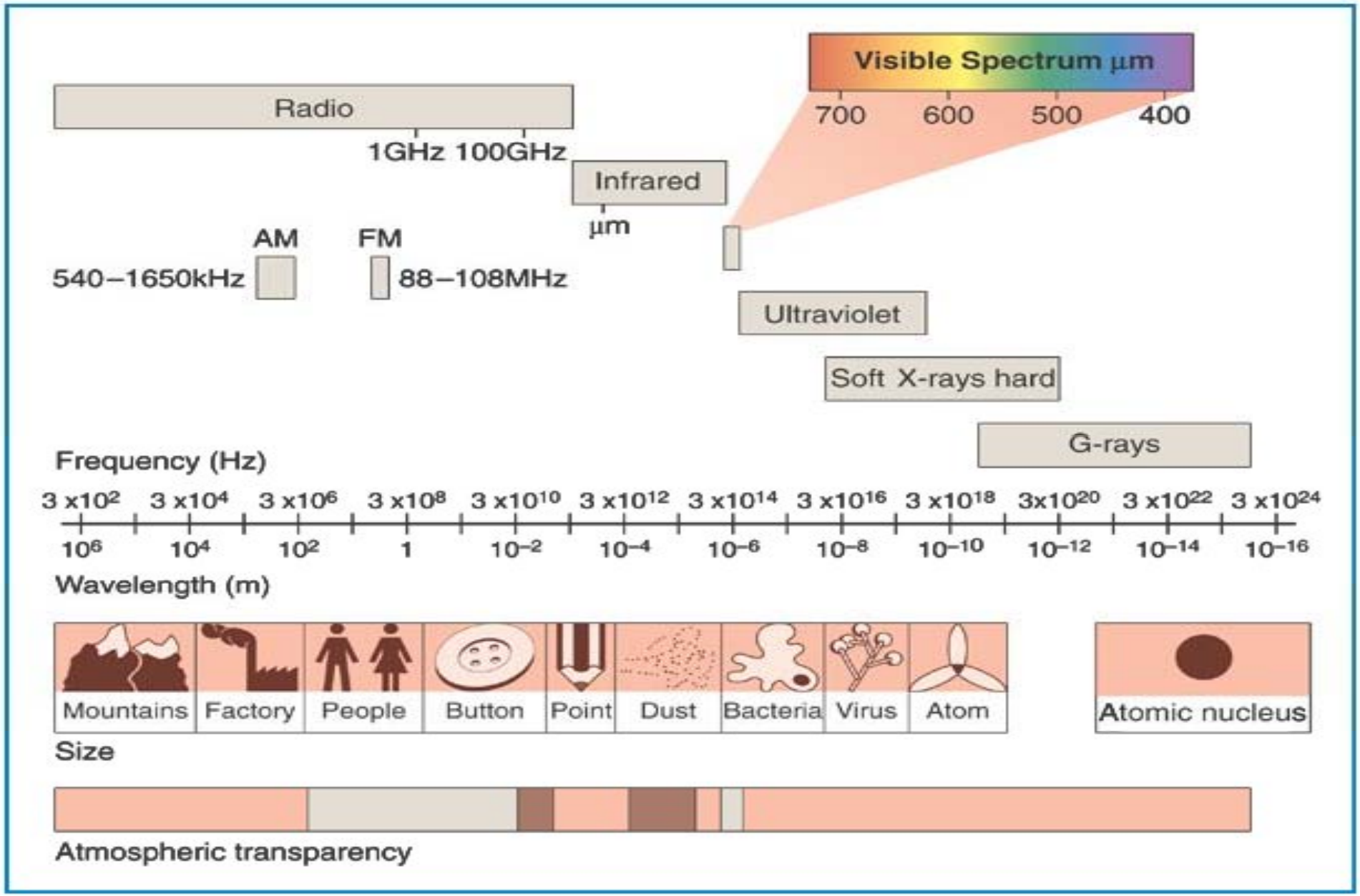
- **Uncorrected refractive error**
- Cataract
- Trachoma

Blindness due to refractive errors is a substantial public health problem in many parts of the world.



How The Eye Works?





(From Miller D, Burns SK: Visable light. In Yanoff M, Duker JS [eds]: *Ophthalmology*, 2nd ed, St. Louis, Mosby, 2004.)

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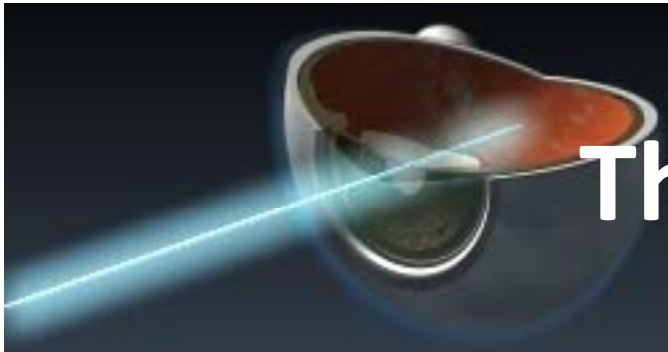
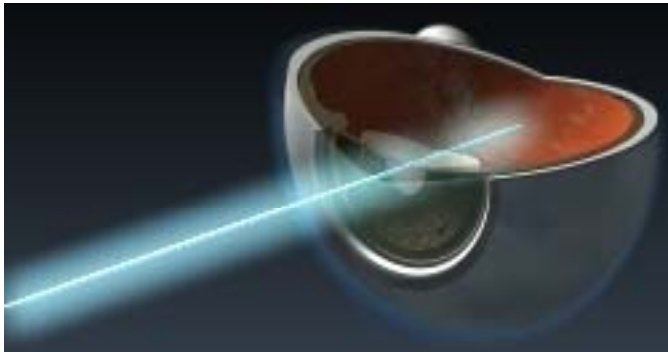
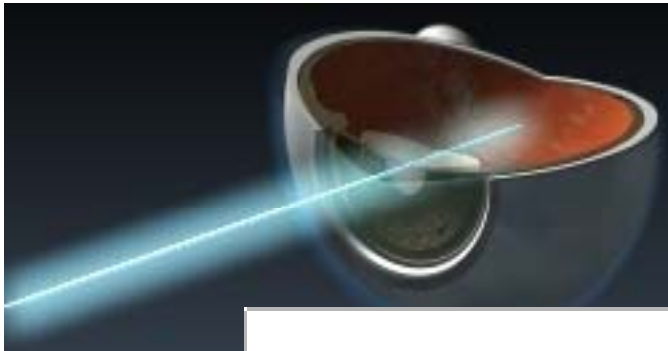


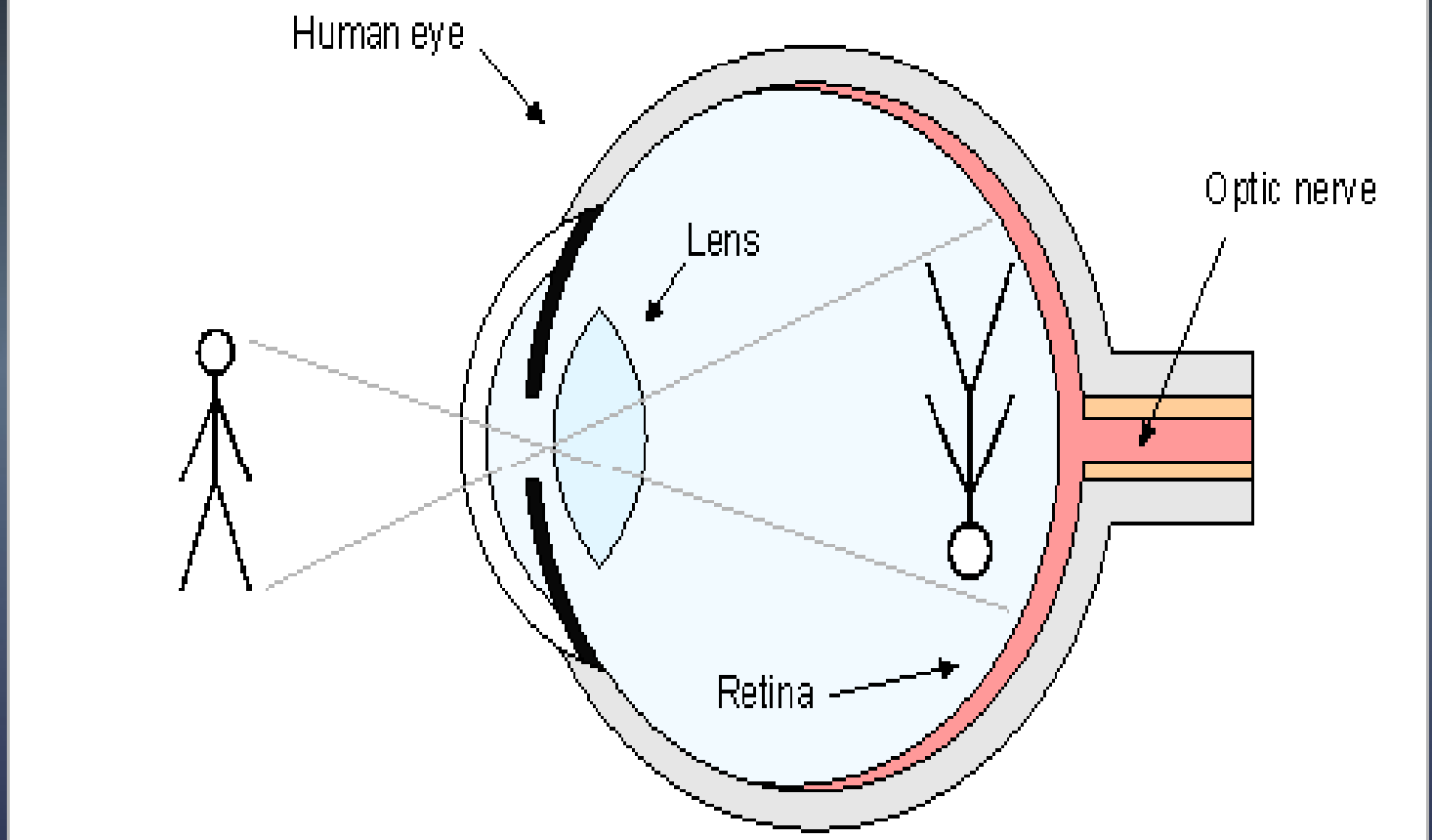
The healthy eye

- Light rays enter the eye through the clear cornea, pupil and lens.
- These light rays are focused directly onto the retina in the same way as a camera focuses light onto a film. (the light sensitive tissue lining the back of the eye)
- The retina converts light rays into impulses; sent through the optic nerve to your brain, where they are recognized as images.

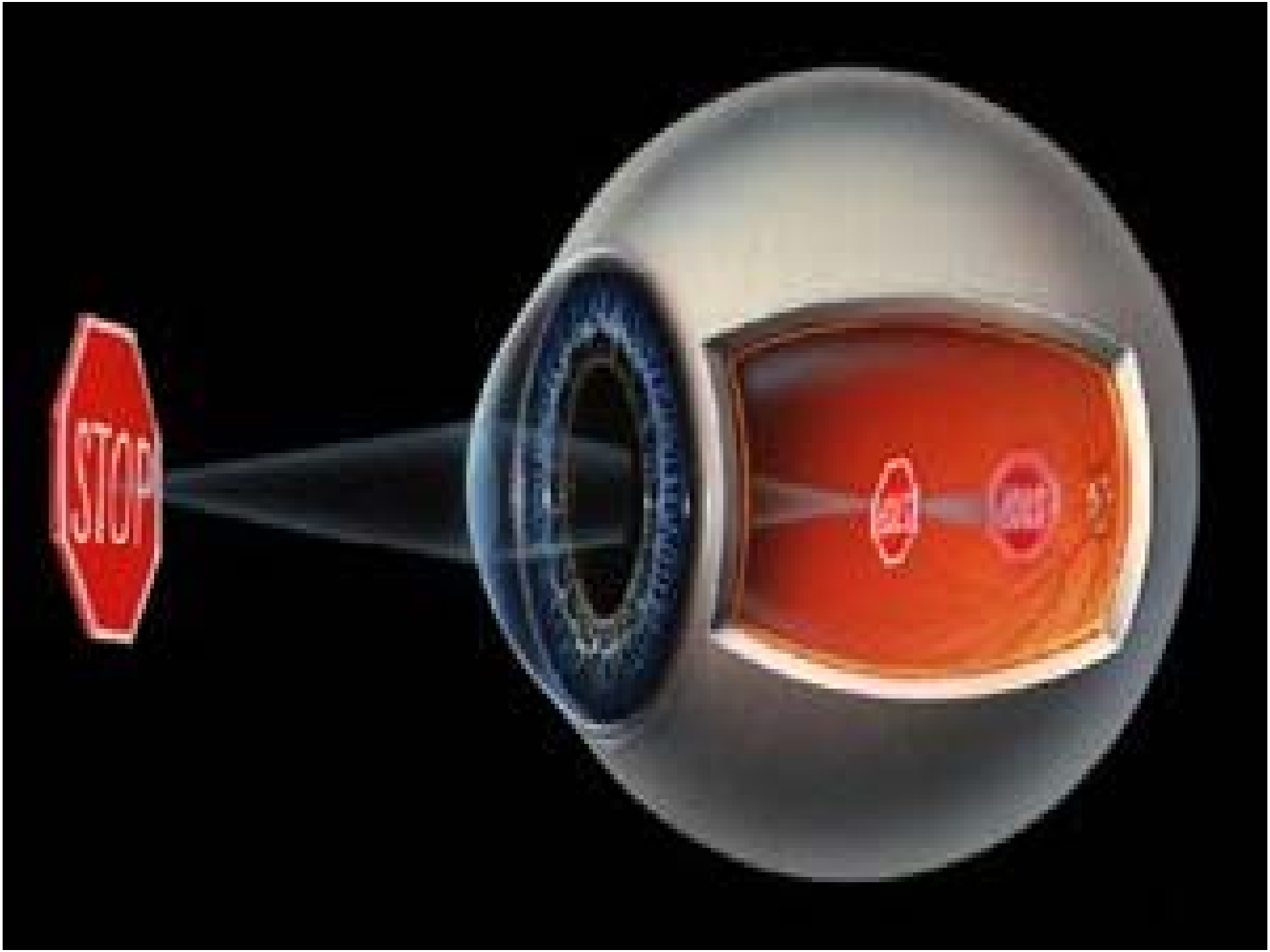


The eye requires about 60 dioptres of power to focus the light from a distant object precisely onto the retina.



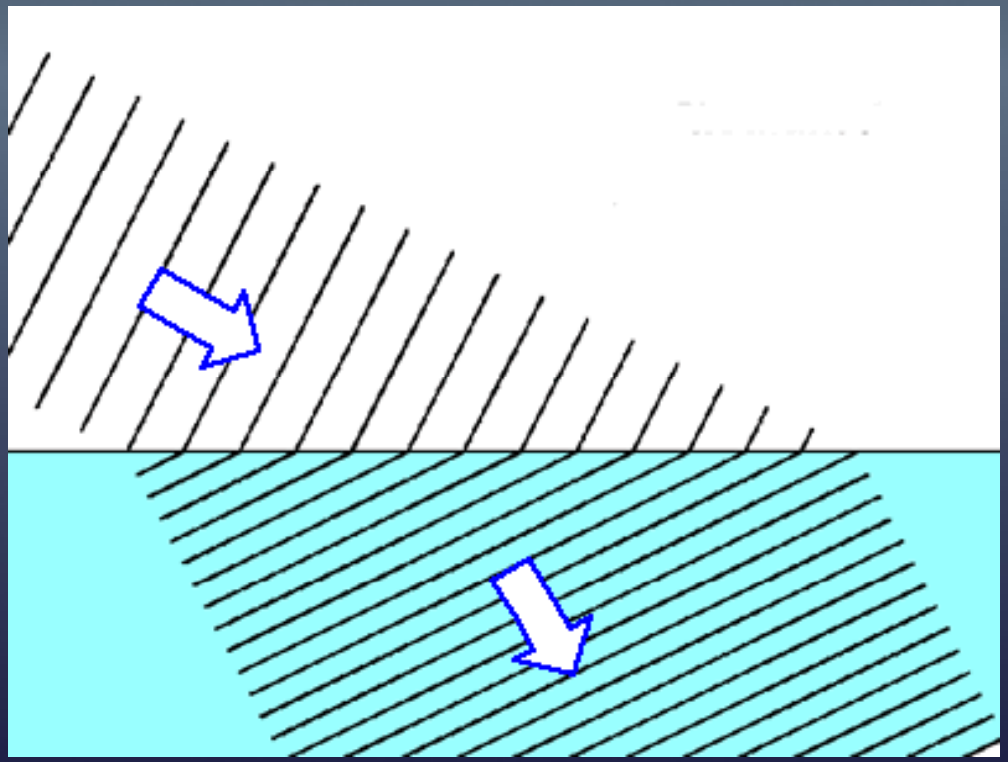


Images are inverted on their way to the retina at the back of the eye


STOP

REFRACTION

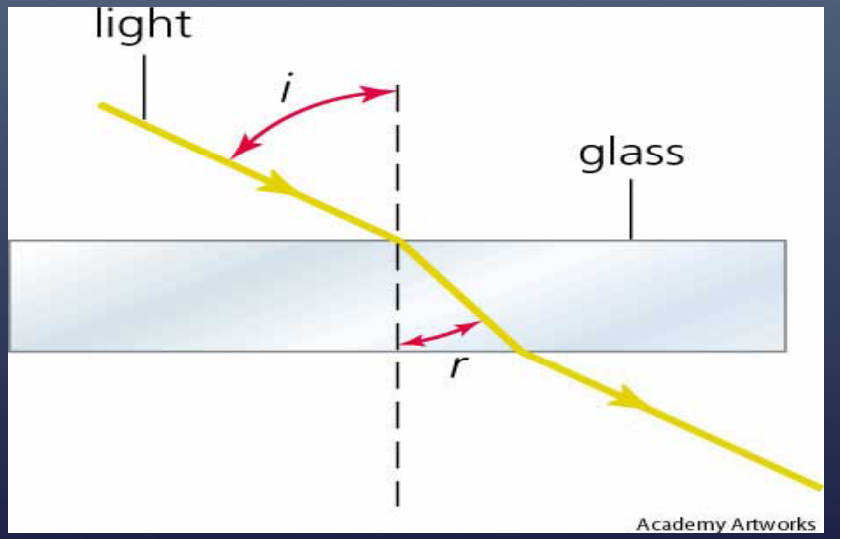
In optics, refraction occurs when light waves travel from a medium with a given refractive index to a medium with another.
At the boundary between the media, the wave's phase velocity is altered, it changes direction.

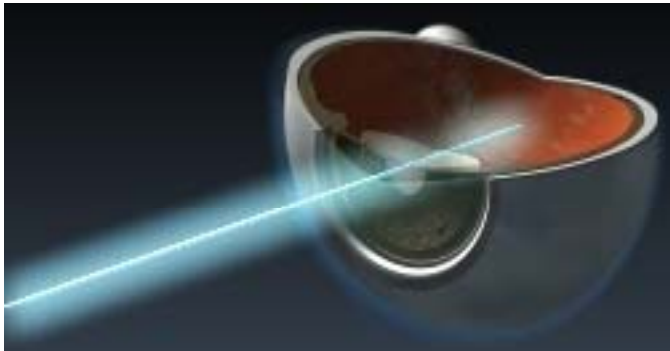


REFRACTION

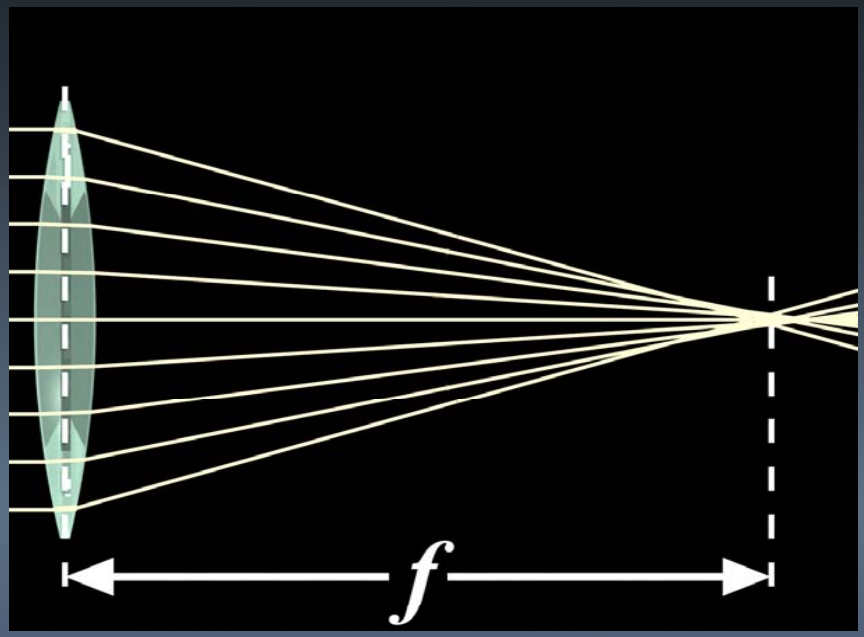
•The amount of bend depends on the refractive index of the media and the angle of incidence

• The refractive index of a medium is defined as the ratio of the phase velocity of a wave light in a reference medium to its velocity in the medium itself.

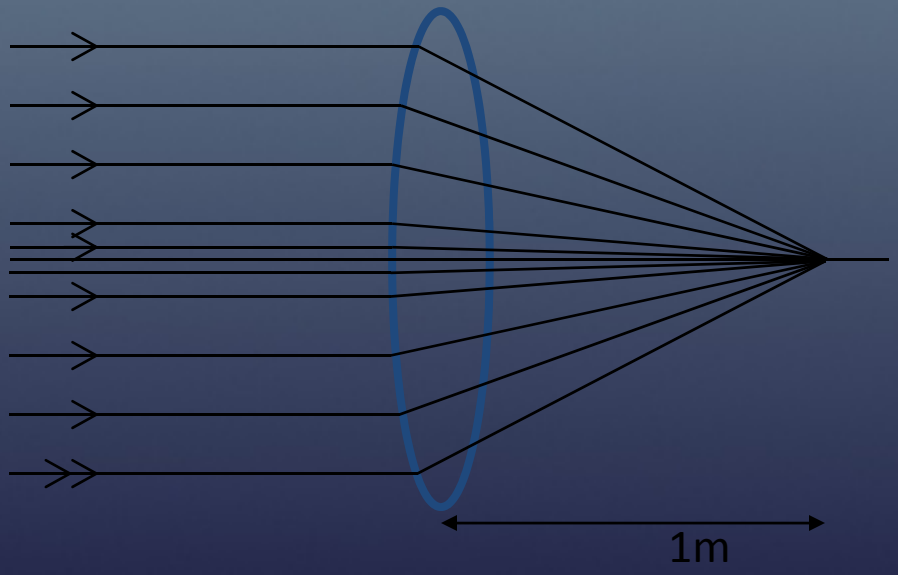


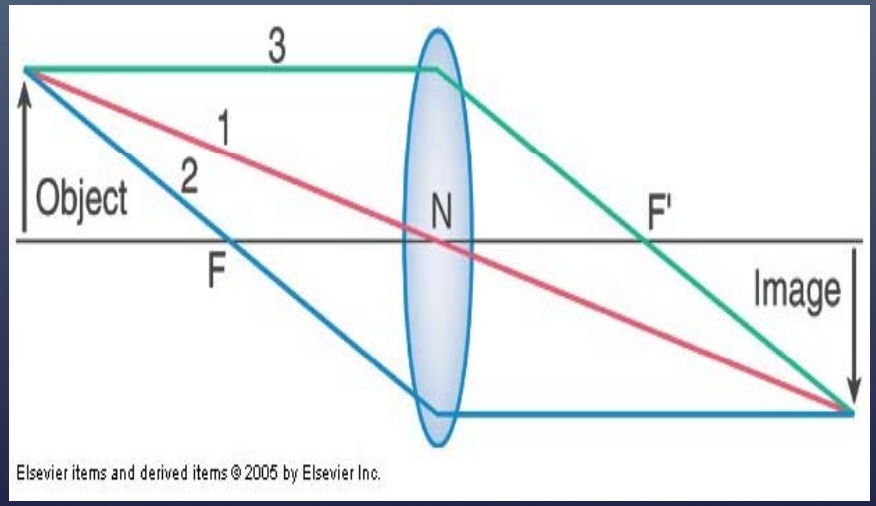


Unit of refraction



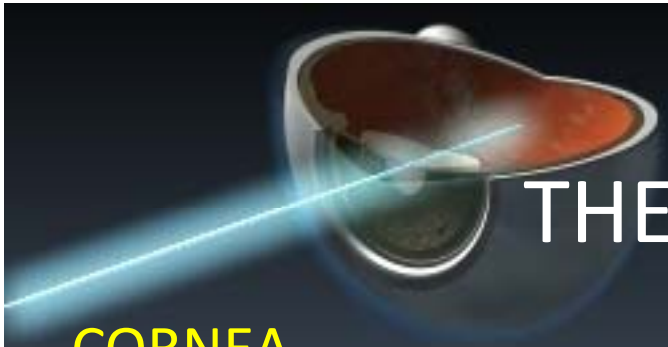
$$\text{Dioptre} = \frac{1}{\text{focal length of a lens}}$$





The power of the lens is measured by the diopter

The unit of refraction



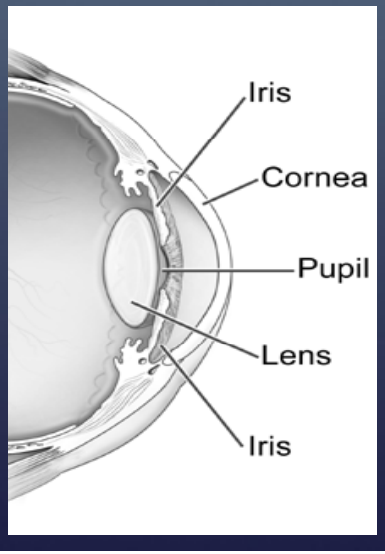
THE EYE'S OPTICAL SYSTEM

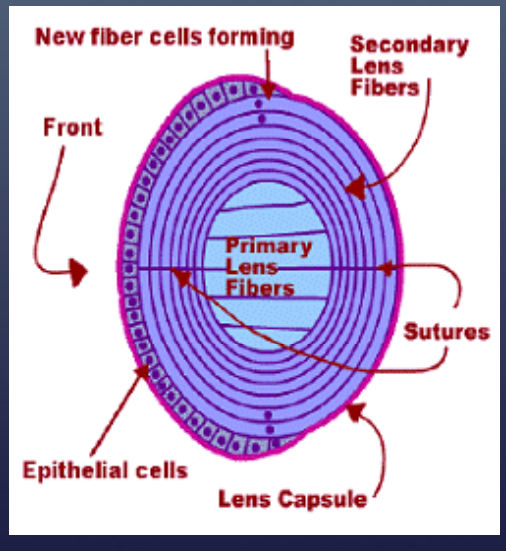
CORNEA

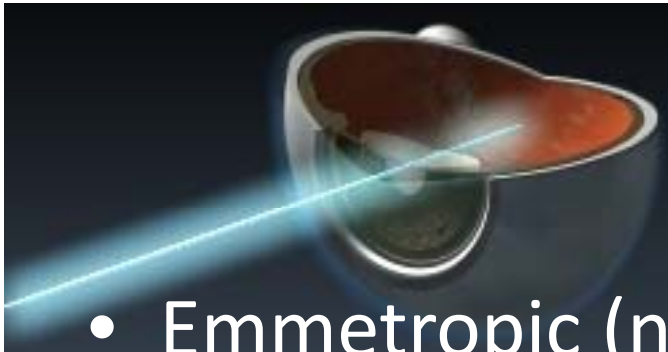
- Main refracting surface
- The cornea provides 40 dioptres, or 75% of the total refracting power of the eye.

CRYSTALINE LENS

- *Double purpose:* balancing eye's refractive power and providing a focusing mechanism
- The lens provides 20 dioptres of refractive power





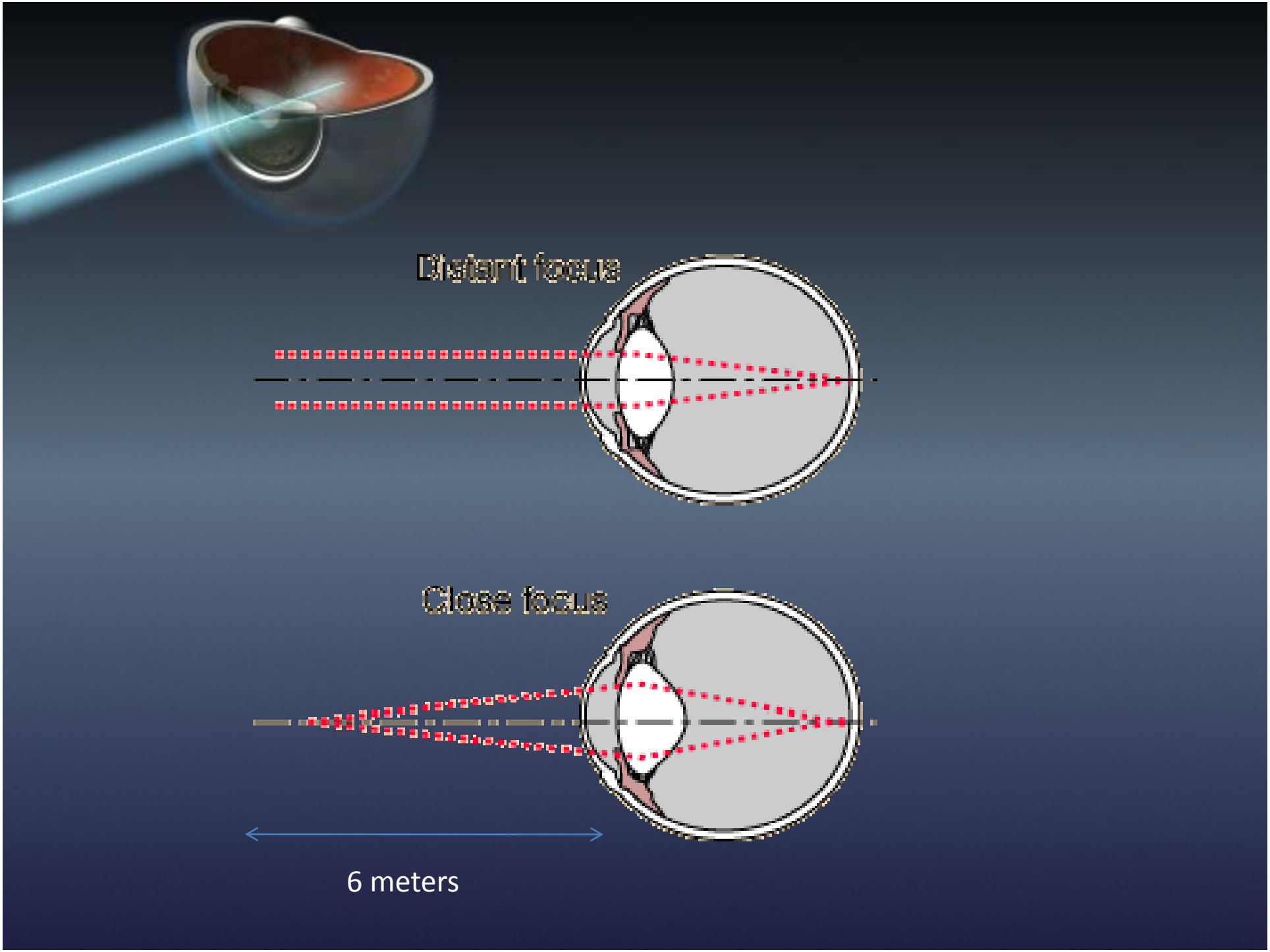


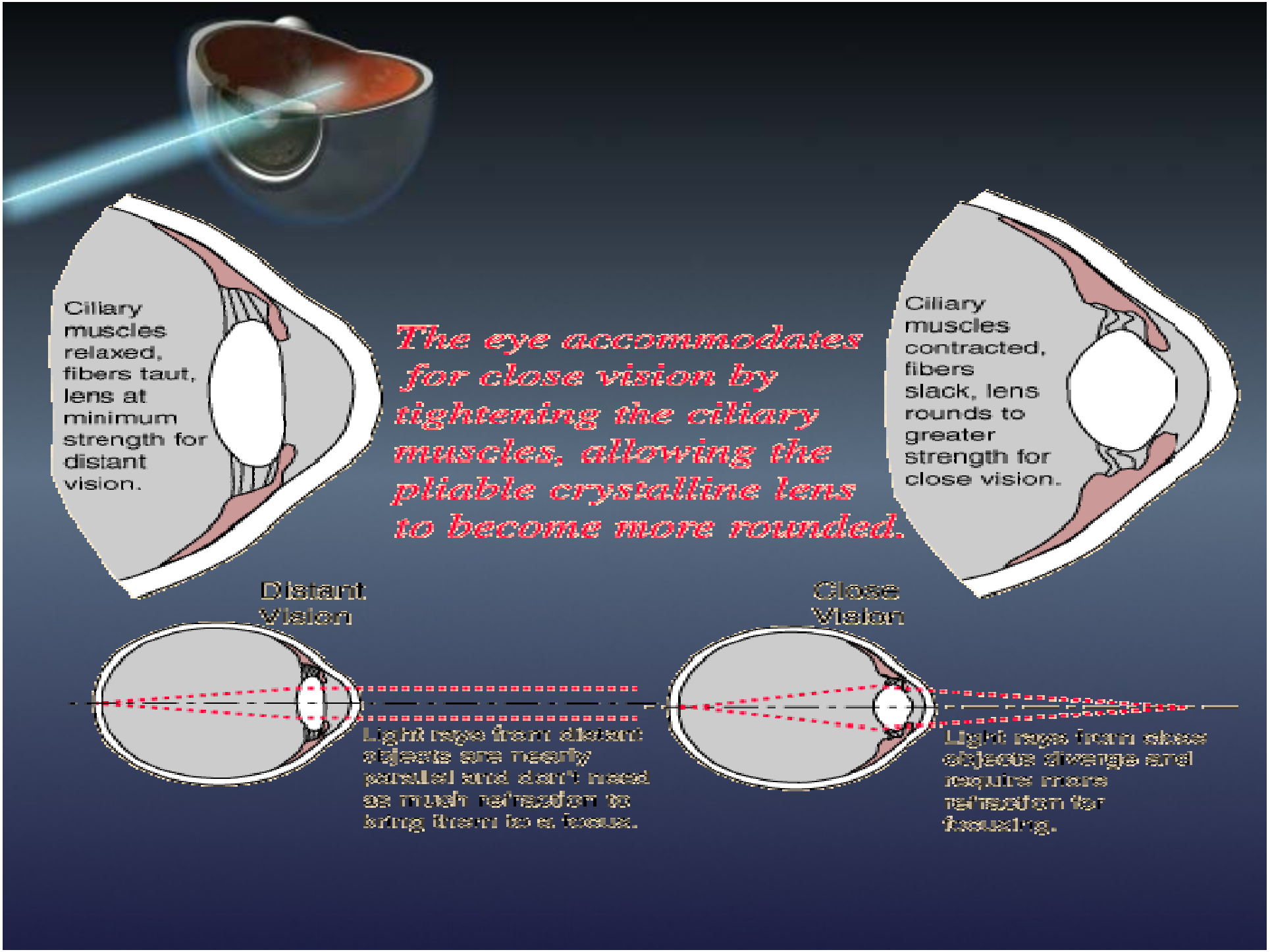
Accommodation

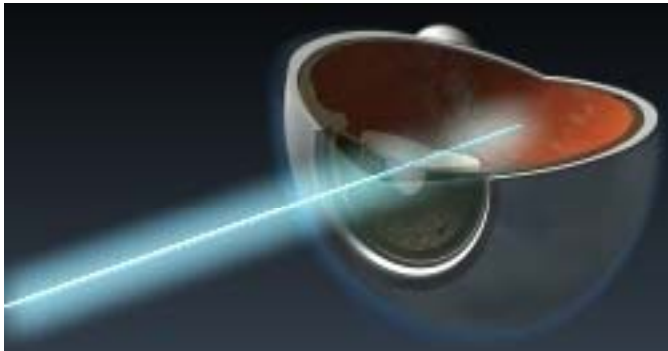
- Emmetropic (normal) eye

  Objects closer than 6 meters send divergent light that focus behind retina , adaptative mechanism of eye is to increase refractive power by accommodation

- Helm-holtz theory
  - contraction of ciliary muscle -->decrease tension in zonule fibers -->elasticity of lens capsule mold lens into spherical shape -->greater dioptic power -->divergent rays are focused on retina
  - contraction of ciliary muscle is supplied by parasympathetic third nerve


Distant focus
Close focus
6 meters


Ciliary muscles relaxed, fibers taut, lens at minimum strength for distant vision.
The eye accommodates for close vision by tightening the ciliary muscles, allowing the pliable crystalline lens to become more rounded.
Ciliary muscles contracted, fibers slack, lens rounds to greater strength for close vision.
Distant Vision
Close Vision
Light rays from distant objects are nearly parallel and don't need as much refraction to bring them to a focus.
Light rays from close objects diverge and require more refraction for focusing.



VISUAL ACUITY

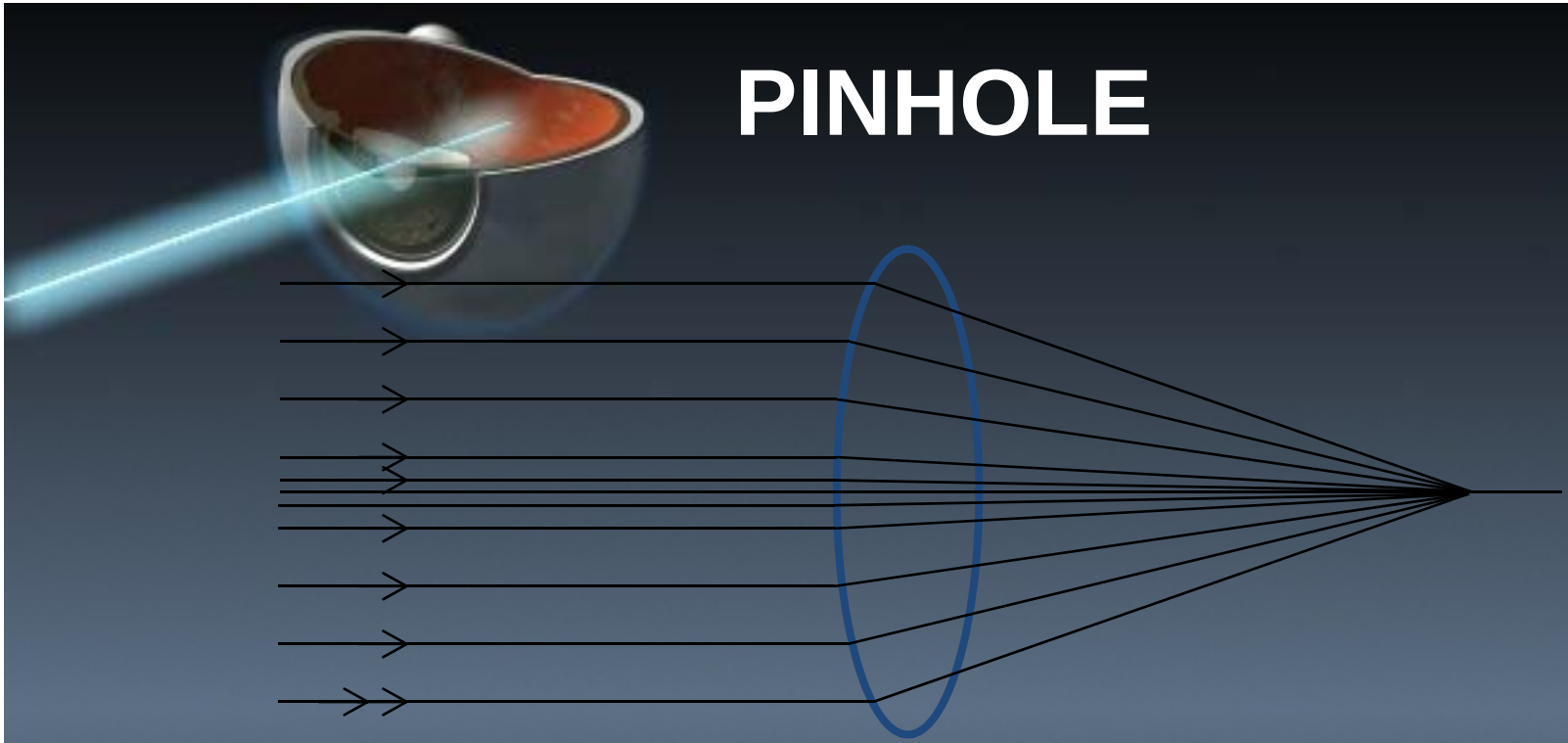
- VA is the vital sign of the eye
- To assess the effect of pathology on VA the effect of refractive error must be eliminated
- This is achieved by measuring:

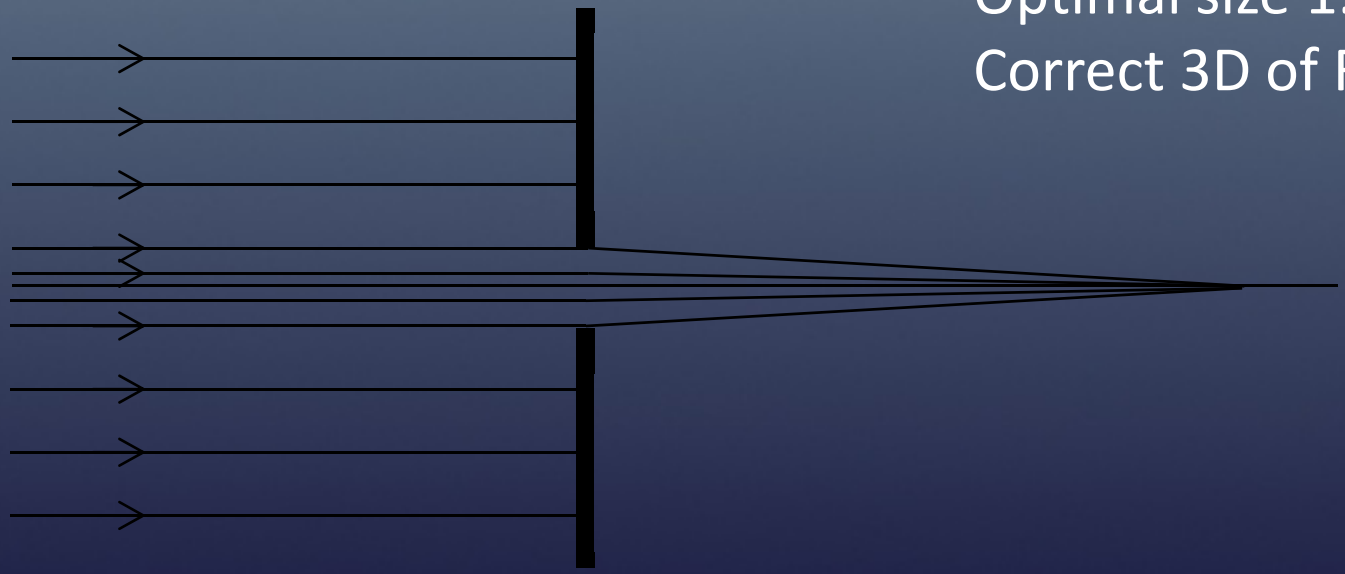
  the patient's best spectacle correction

  or

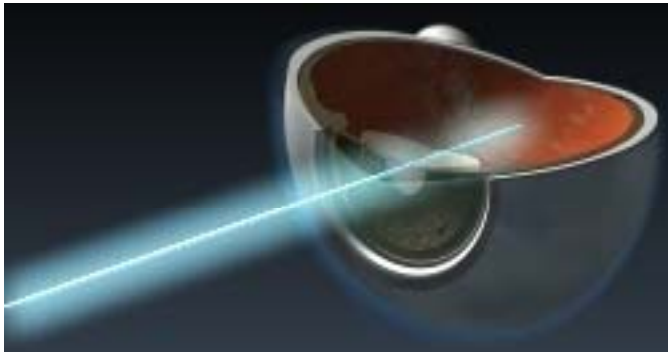
  viewing the test chart through a pinhole

PINHOLE





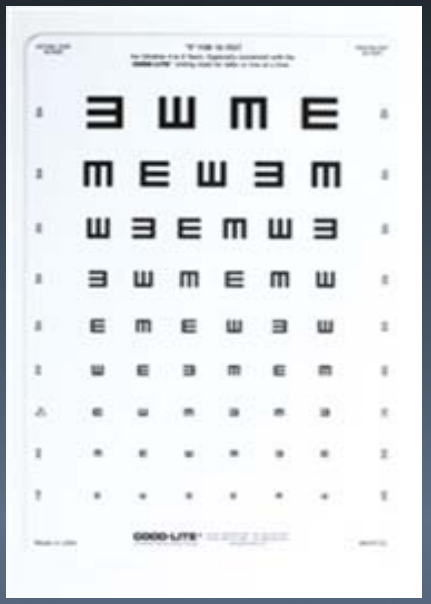
Optimal size 1.2mm
Correct 3D of RE

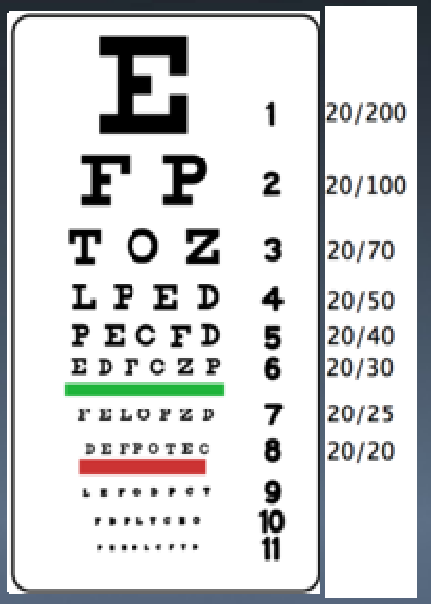


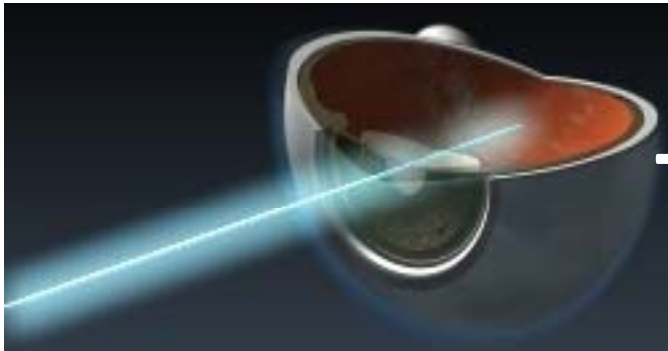
How to test the vision?

Central visual acuity

- display of different –sized targets shown at a standard distance from the eye.
- Snellen chart.
- 20/20, 6/6







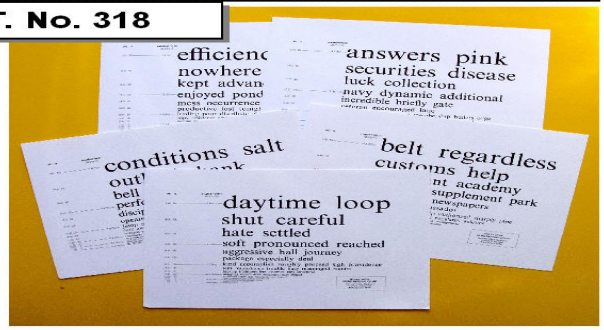
Testing poor vision

- If the patient is unable to read the largest letter <(20/200)
- Move the patient closer e.g. 5/200
- If patient cannot read:
  - Count fingers (CF)
  - Hand motion (HM)
  - Light perception (LP)
  - No light perception (NLP)

NEAR VISUAL ACUITY

BAILEY LOVIE READING CHARTS

CAT. No. 318

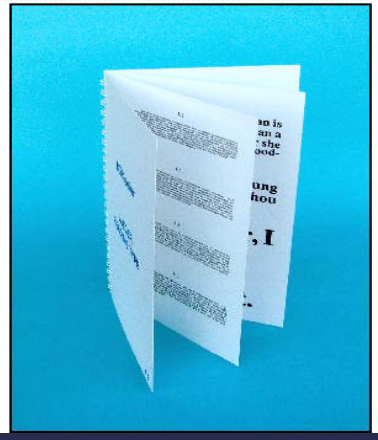


BAILEY LOVEY READING CARDS
A set of 5 charts showing different word sequences on a plain white surface. Over 17 different sizes of text equivalents from N2 to N80. Instructions are included for special testing procedures, e.g. for establishing reading speed as well as acuity

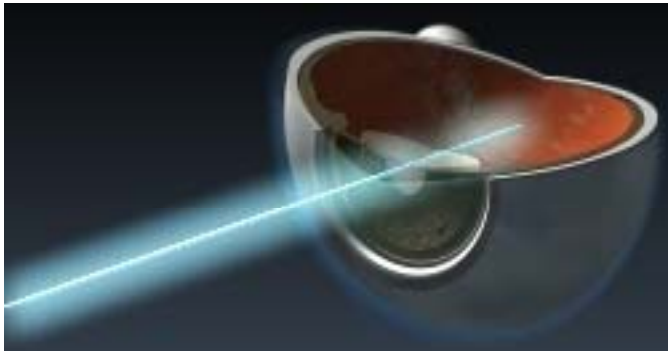
Size of charts 215 x 279 mm.

VOCATIONAL READING TEST TYPE

CAT. No. 302

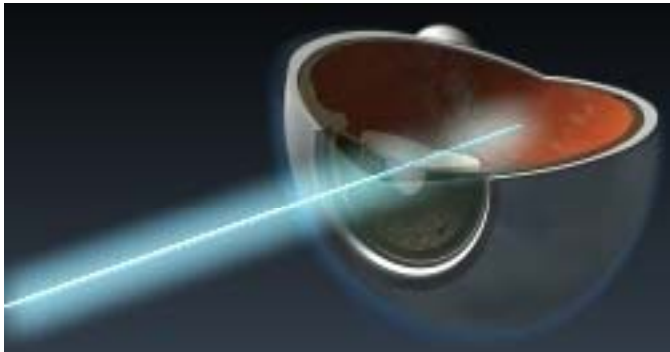


- At a standard working distance ~ 30-40 cm
- A variety of charts are available



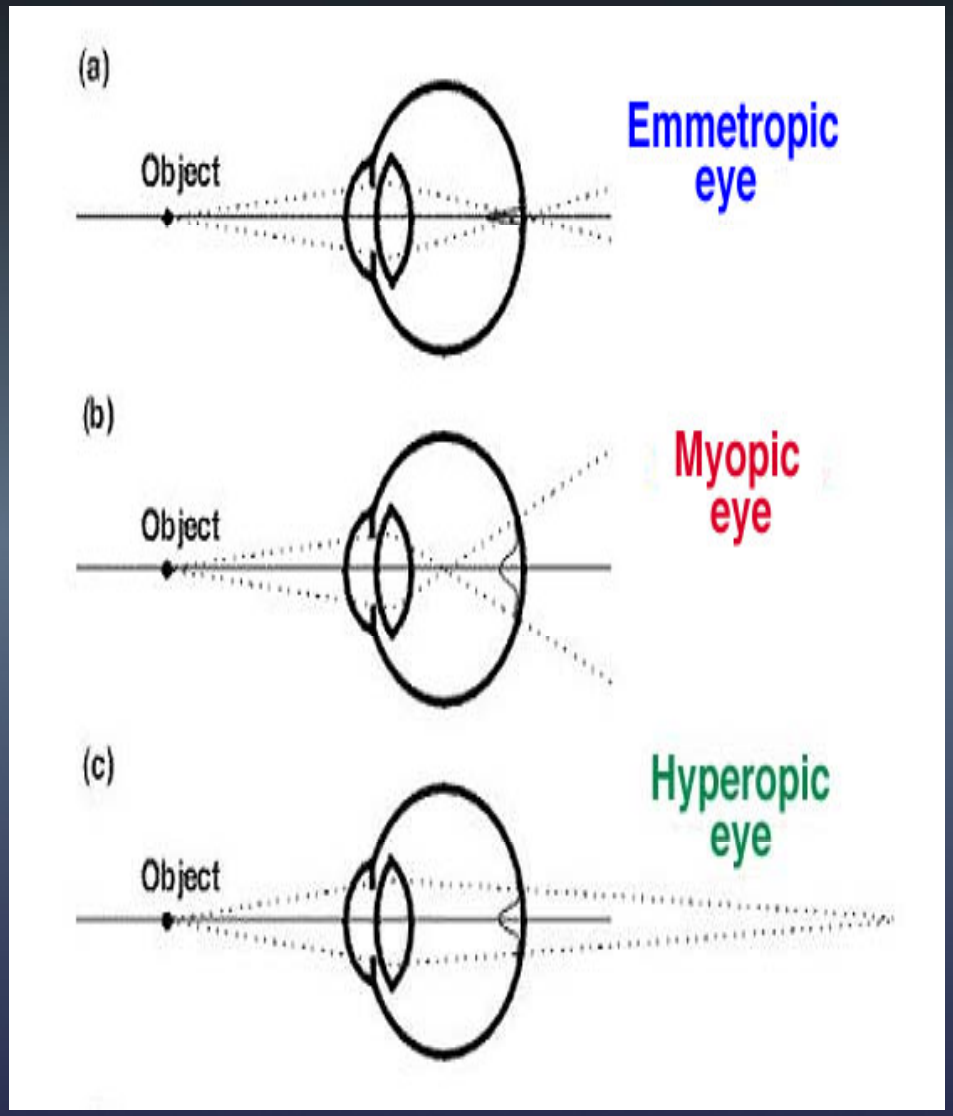
Refractive errors

- A mismatch between the refractive power and the focusing distance of the eye
- Inability to see clearly is often caused by refractive errors.
- three types of refractive errors:
  - Myopia (nearsightedness)
  - Hyperopia (farsightedness)
  - Astigmatism



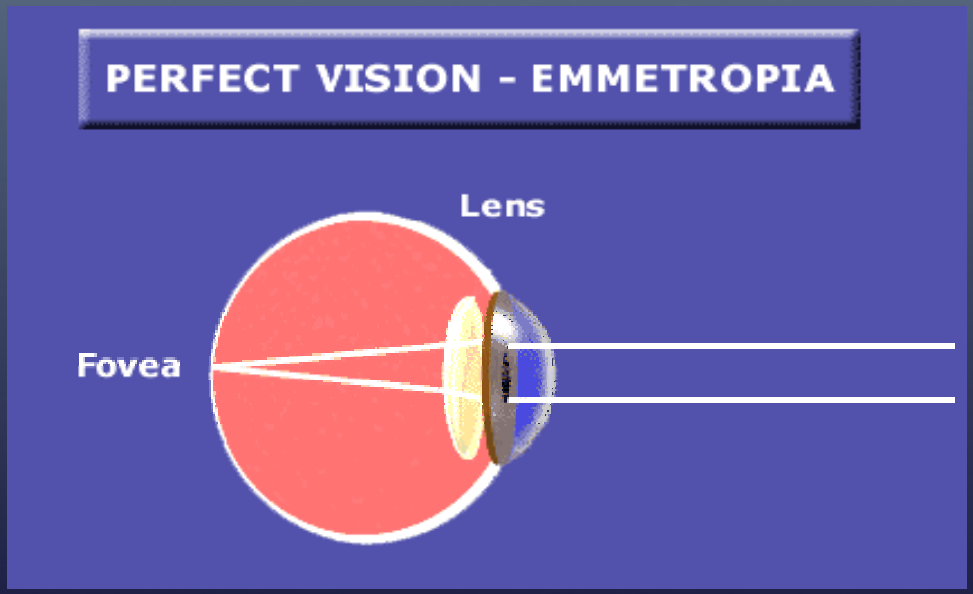
REFRACTIVE ERROR

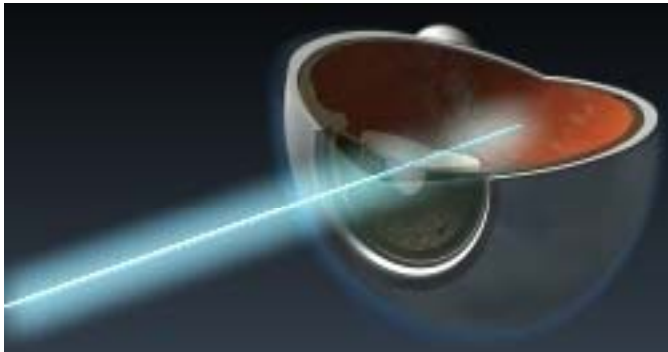
- Emmetropia (normal)
- Ametrpia=RE
  - Myopia
  - Hyperopia
  - Astigmatism



Emmetropia

- Adequate correlation OR matching between axial length and refractive power of the eye
- Rays of light from a distant object are brought to a pin-point sharp focus on the retina (no accommodation)
- All refractive errors are some deviation from emmetropia





MYOPIA

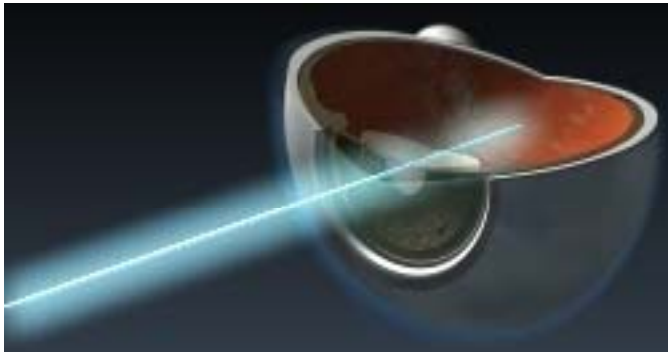
- Most prevalent among Asians (80-90%) followed by 25% of African Americans and 13% of Caucasians.

- Average age of onset: 8 years

- Etiology : not clear, genetic factor

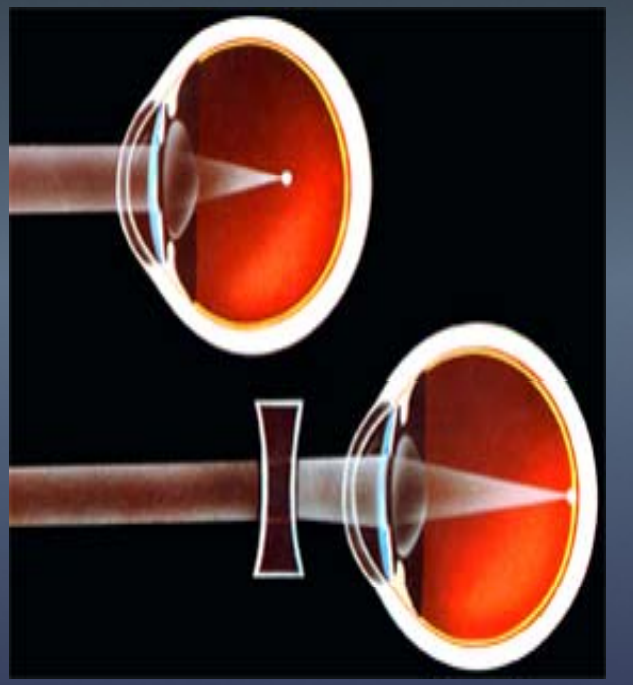
- Causes:

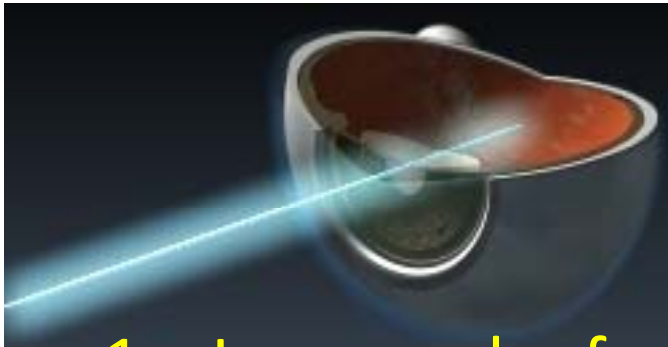
  excessive refractive power (refractive myopia)
  excessive long globe (axial myopia) : ‘’more common’’



MYOPIA

- Rays of light from distant objects converge in front of the retina, causing a blurred image on the retina
- The myopes can see close objects clearly, myopia is commonly known as “short-sightedness”





Causes of myopia

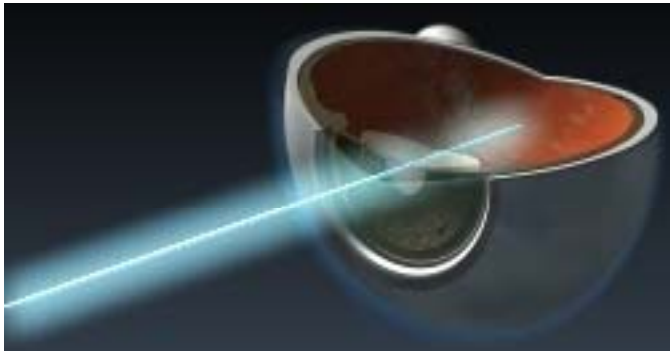
1. Increased refractive power:

a) Change in lens nucleus or shape:
cataract, spherophakia, diabetes

b) Lens repositioning:
ciliary muscle shift e.g miotics
lens movement e.g anterior lens dislocation

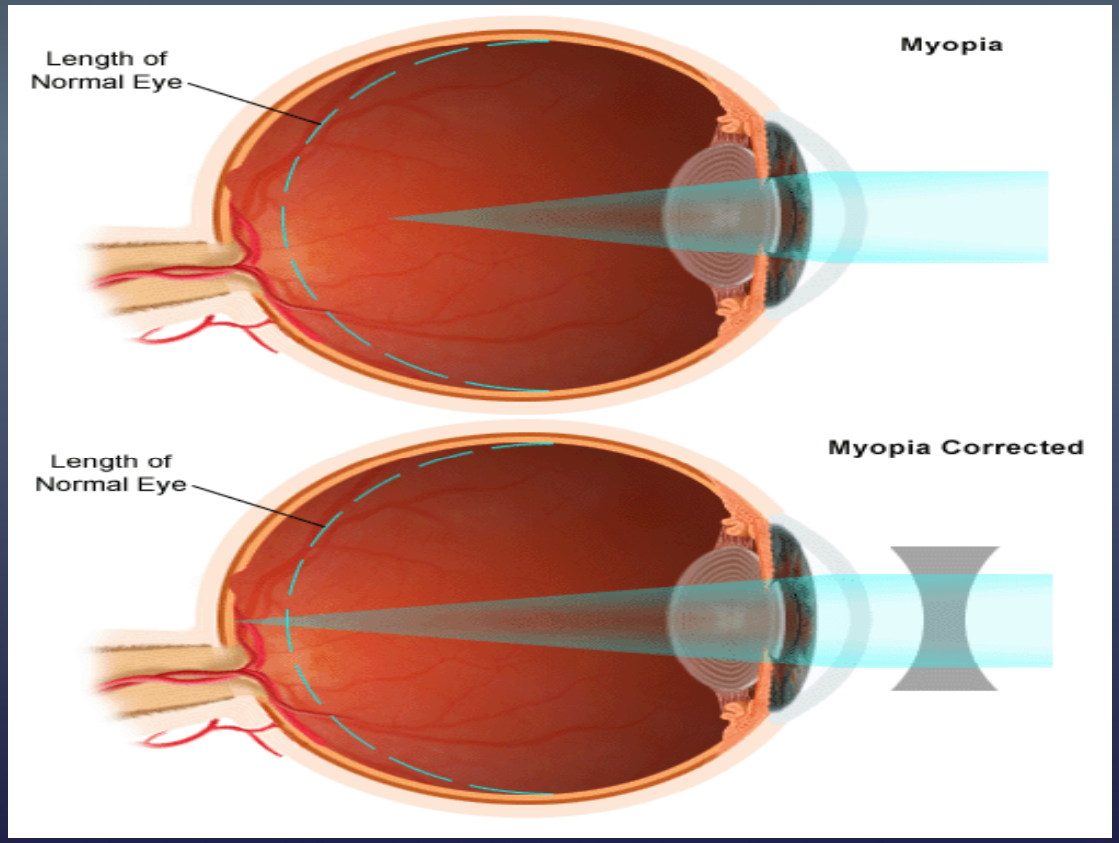
c) Ciliary muscle tone:
excessive accommodation e.g medical students

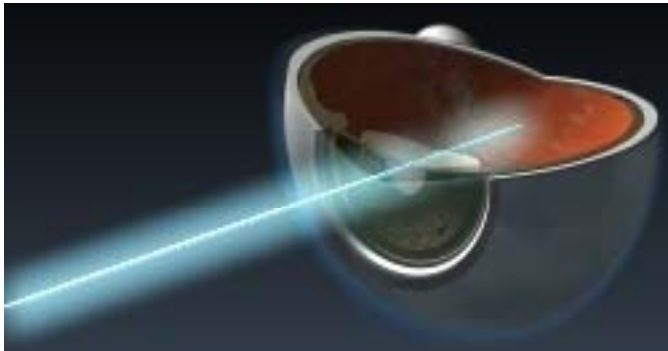
d) Increase corneal power:
keratoconus, congenital glaucoma



2. Increase axial length:

congenital glaucoma, posterior staphyloma

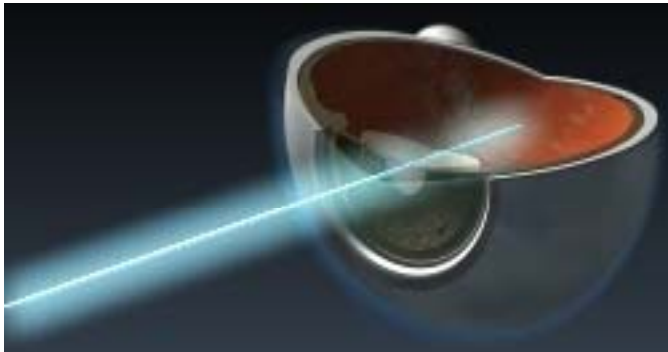




Myopia

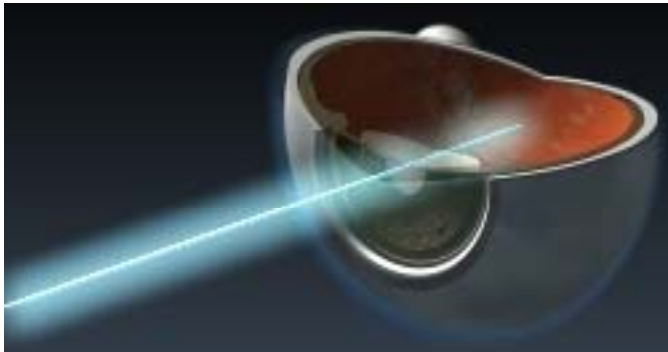
Myopia Forms:

- Benign myopia (school age myopia)
  - onset 10-12 years , myopia increase until the child stops growing in height
  - generally tapers off at about 20 years of age
- Progressive or malignant myopia
  - myopia increases rapidly each year and is associated with , fluidity of vitreous and chorioretinal change

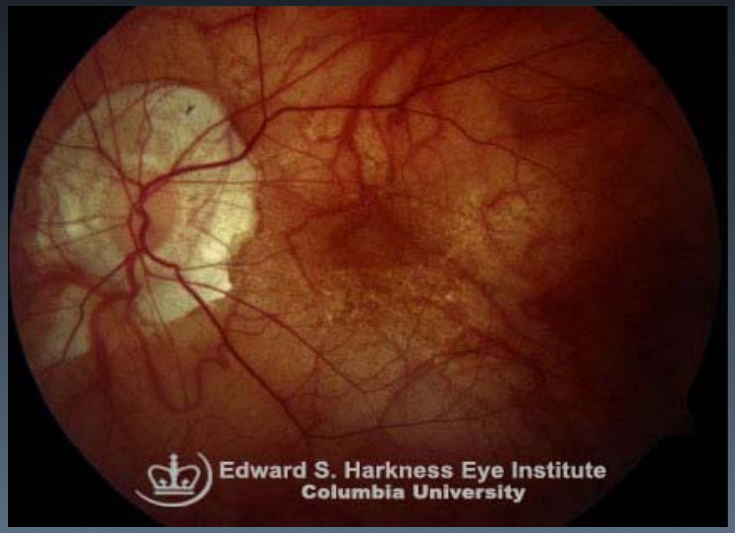


Myopia

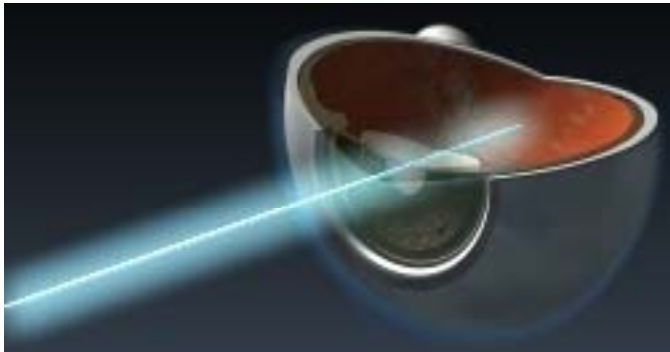
- Symptoms
  - Blurred distance vision
  - Squint in an attempt to improve uncorrected visual acuity when gazing into the distance
  - Headache
  - Amblyopia – uncorrected myopia > -10 D



Myopia



- Morphologic eye changes:
  - Deep anterior chamber
  - Atrophy of ciliary muscle
  - Vitreous may collapse prematurely -->opacification
  - Fundus changes: loss of pigment in RPE , large disc and white crescent-shaped area on temporal side , RPE atrophy in macular area , posterior staphyloma , retinal degeneration-->hole-->increase risk of RD



Hyperopia

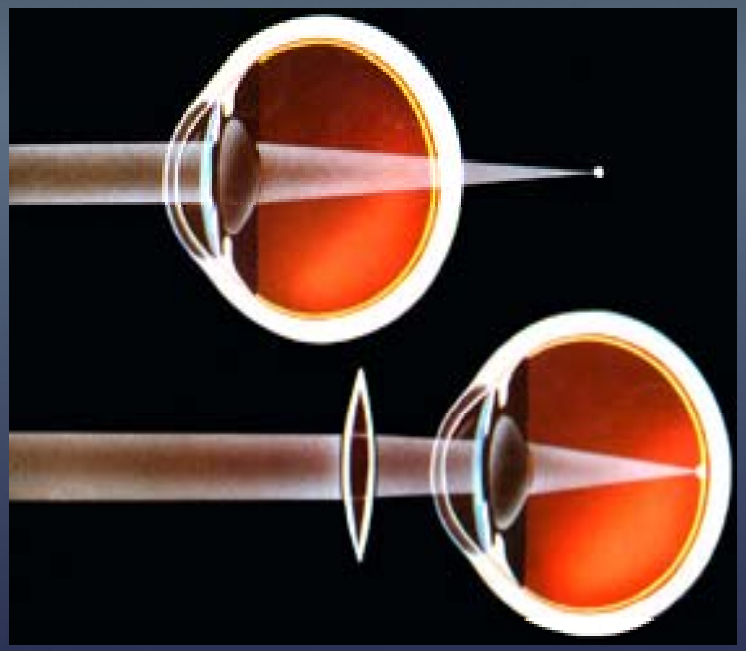
- Parallel rays converge at a focal point posterior to the retina
- Etiology : not clear , inherited
- Causes
  - excessive short globe (axial hyperopia) : more common
  - insufficient refractive power (refractive hyperopia)

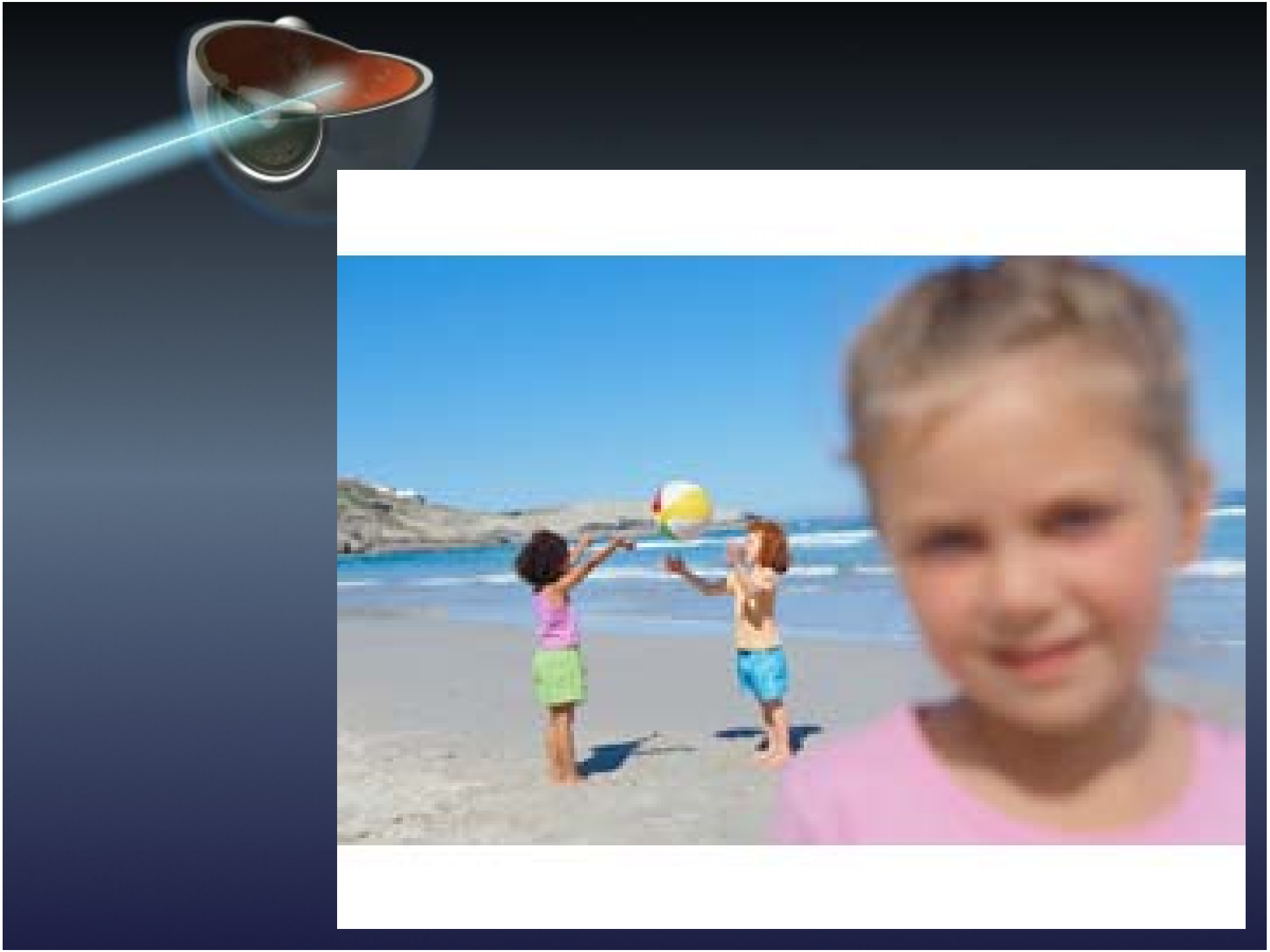
HYPEROPIA

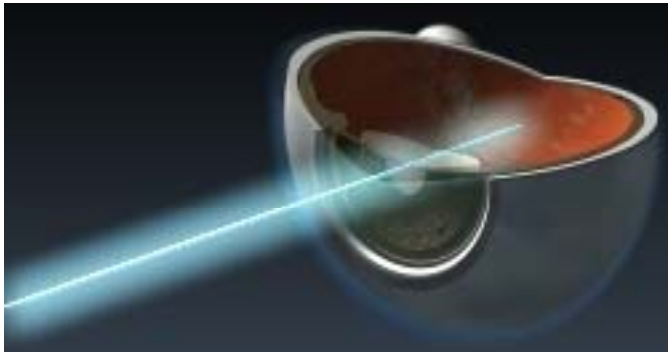
- Rays of light from a distant object now focus behind the retina

- hyperopic persons must accommodate when gazing into distance to bring focal point on to the retina

- However, this reduces their accommodative reserve when they want to view close objects. This means their distance vision is generally better than their near vision, hence the term “long-sightedness”



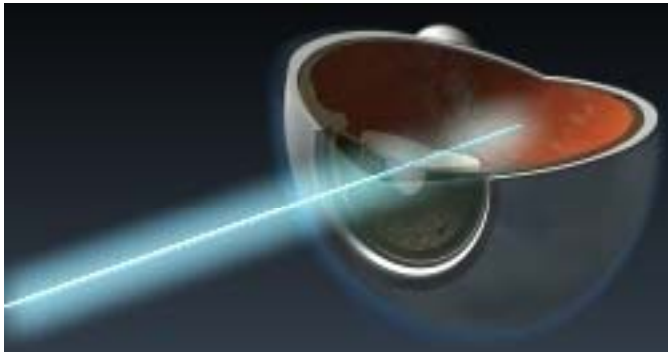




Causes of Hyperopia

1. Decreased refractive power of the eye:
    a) absent (aphakia) or posteriorly repositioned lens
    b) weak accommodation trauma, marijuana

2. Decreased effective axial length(retina pushed forward):
    tumor, orbital mass

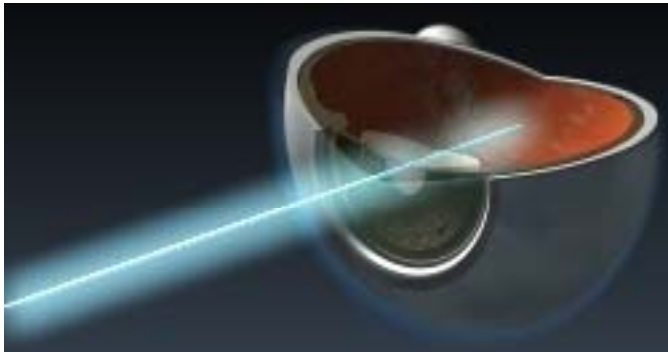


Hyperopia

Symptoms

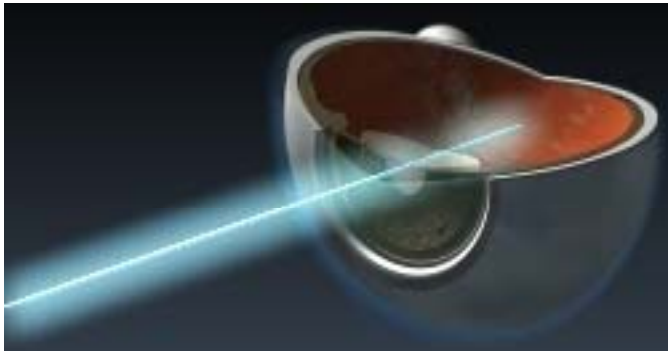
- Visual acuity at near tends to blur relatively early

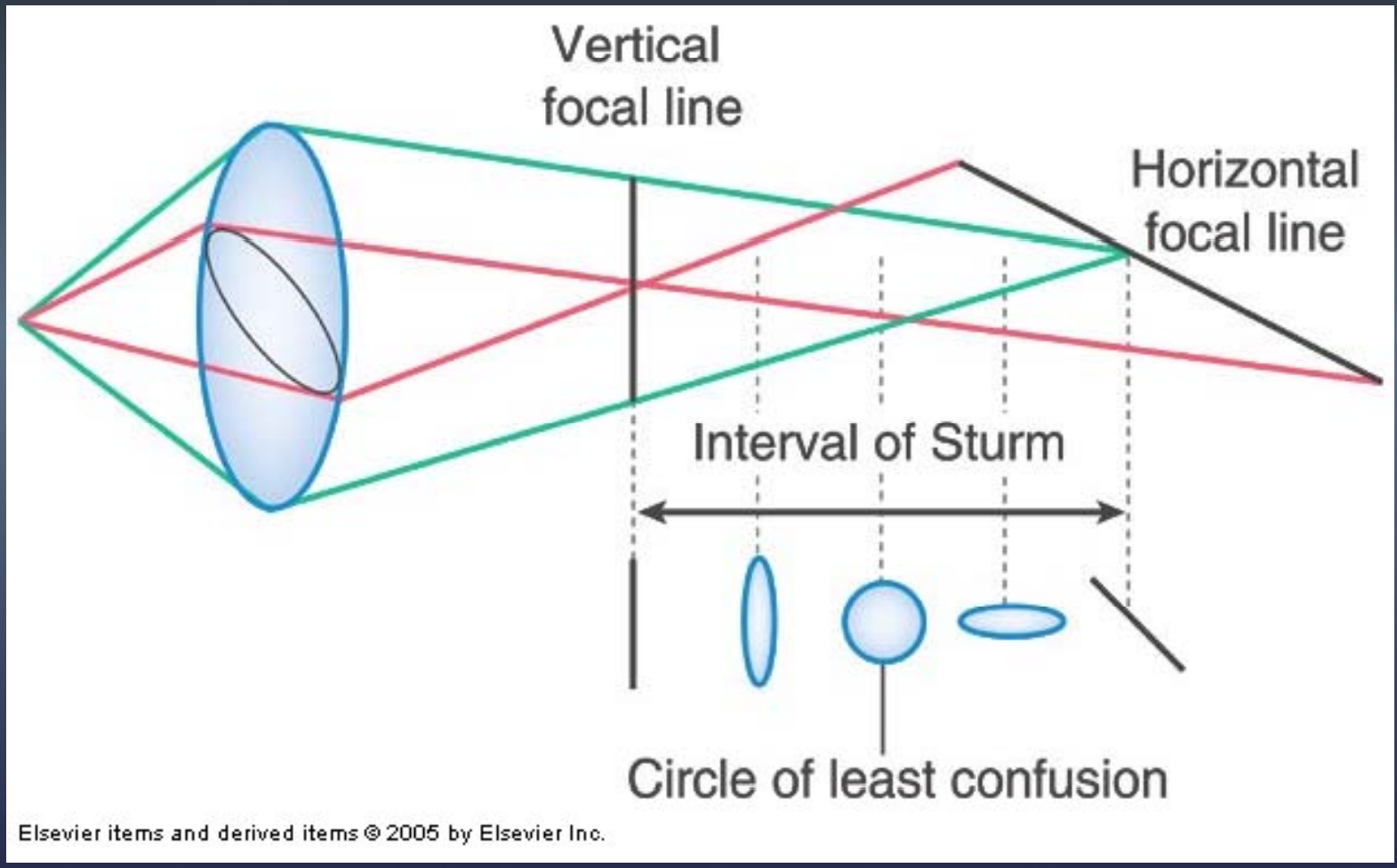
  ‘’inability to read fine print’’
- Asthenopic symptoms : eyepain, headache in frontal region
- Accommodative esotropia : because accommodation is linked to convergence -->ET
- Amblyopia – uncorrected hyperopia > +5D



ASTIGMATISM

- Cornea is usually shaped like half a football. In these eyes there will be no astigmatism.
- Parallel rays come to focus in 2 focal lines rather than a single focal point
- Etiology : hereditry
- Cause : refractive media is not spherical-->refract differently along one meridian than along meridian perpendicular to it-->2 focal





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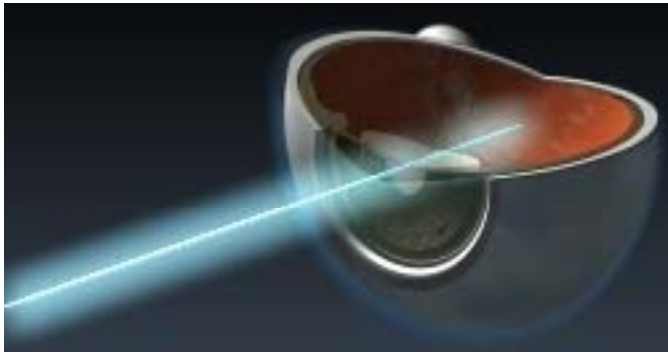
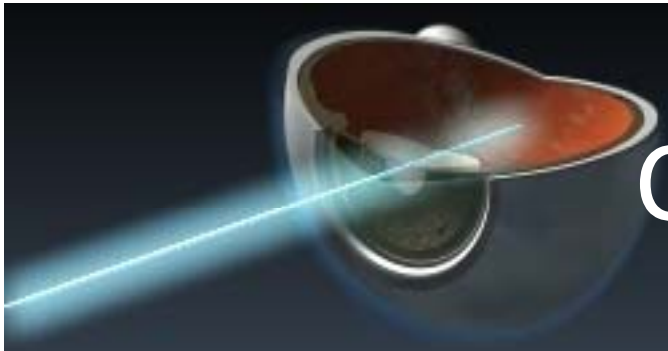


Astigmatism

- Classification
  - Regular astigmatism: power and orientation of principle meridians are constant
    - With the rule astigmatism , Against the rule astigmatism , Oblique astigmatism
  - Irregular astigmatism : power and orientation of principle meridians change across the pupil



Causes of astigmatism

Corneal causes:

a) simple corneal astigmatism

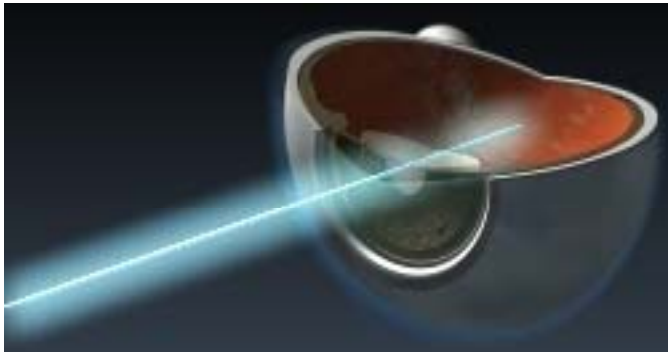
b) Keratoconus

c) Masses e.g lid tumor

d) Ptosis

Lenticular causes:

Lens dislocation, lenticonus

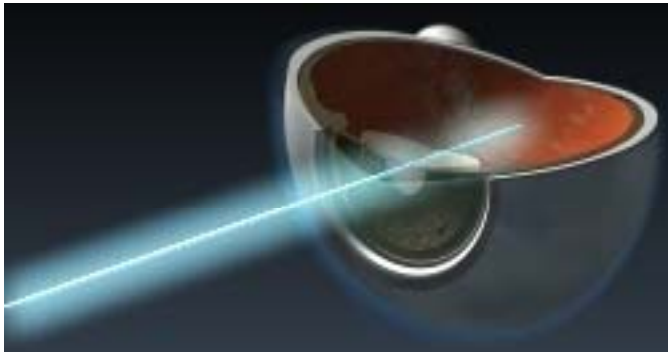


Astigmatism

- Symptoms
  - asthenopic symptoms (headache , eye pain)
  - blurred vision
  - distortion of vision
  - head tilting and turning
  - Amblyopia – uncorrected astigmatism > 1.5 D

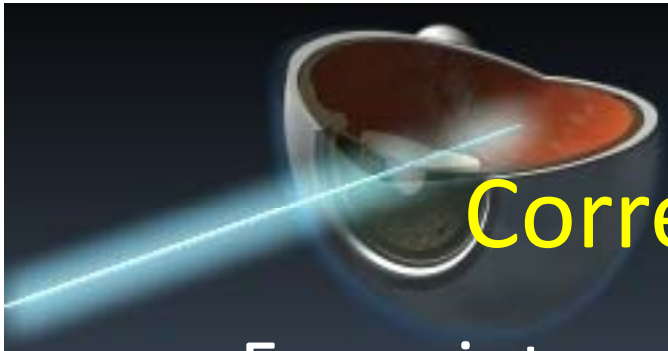
ANISOMETROPIA

- A difference in refractive error between the two eyes
- Individuals can tolerates up to 2-3D of anisometropia before becoming symptomatic
- Refractive correction often leads to different image sizes on the 2 retinas (aniseikonia)
- Aniseikonia depend on degree of refractive anomaly and type of correction



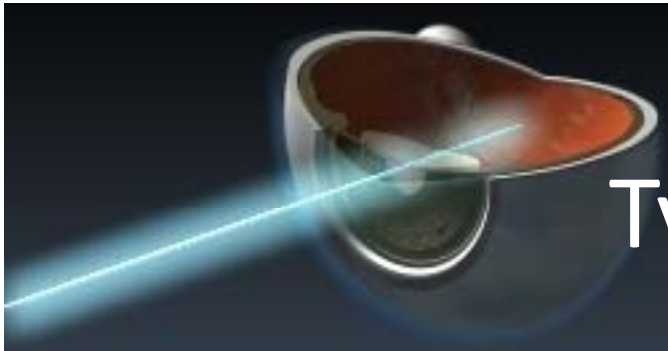
Presbyopia

- Physiological loss of accommodation in advancing age
- Deposit of insoluble proteins in the lens with advancing age-->elasticity of lens progressively decrease-->decrease accommodation
- around 40 years of age , accommodation become less than 3 D-->reading is possible at 40-50 cm-->difficultly reading fine print , headache , visual fatigue



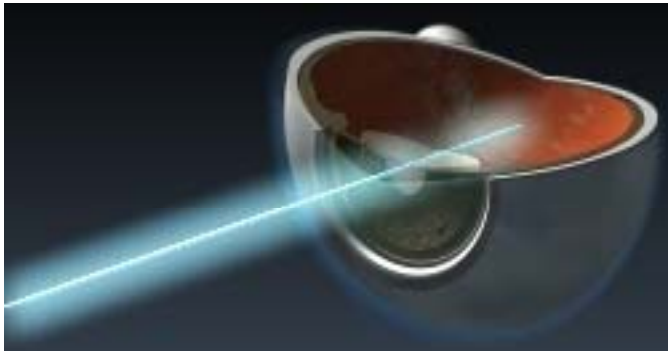
Correction of refractive errors

- Far point: a point on the visual axis conjugate to the retina when accommodation is completely relaxed
- placing the imaging of the object at far point will cause a clear image of that object to be relayed to the retina
- use correcting lenses to form an image of infinity at the far point , correcting the eye for distance

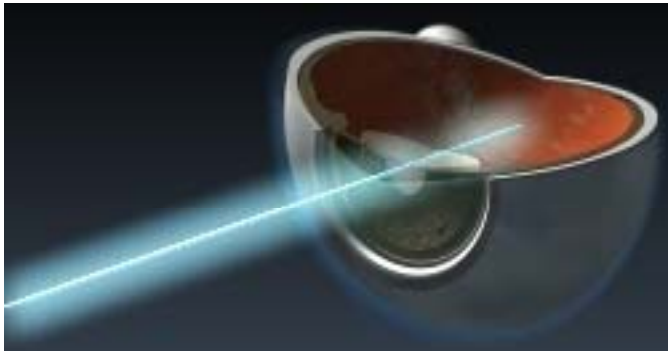


Types of optical correction

- Spectacle lenses
  - Monofocal lenses : spherical lenses , cylindrical lenses
  - Multifocal lenses
- Contact lenses
  - higher quality of optical image and less influence on the size of retinal image than spectacle lenses
  - indication : cosmetic , athletic activities , occupational , irregular corneal astigmatism , high anisometropia , corneal disease



- Contact lenses
  - disadvantages : careful daily cleaning and disinfection , expense
  - complication : infectious keratitis , giant papillary conjunctivitis , corneal vascularization , severe chronic conjunctivitis



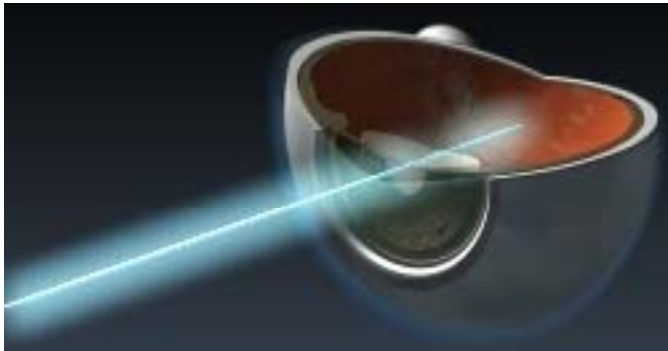
Surgical correction

Keratorefractive surgery :

- Refractive surgery – flattens corneal surface for myopia
- Improves unaided visual acuity but may have complications
  e.g PRK, LASIK,LASEK

Intraocular surgery :

- give best optical correction for aphakia , avoid significant magnification and distortion caused by spectacle lenses
- clear lens extraction (with or without IOL), phakic IOL



LASIK – State of the Art

Laser

Assisted

Stromal

In-situ

Keratomileusis