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Seeing the World of Eye

The first World Sight Day was held on 8 October 1998. Later, the event was integrated into VISION 2020, a global initiative coordinated by the International Agency for the Prevention of Blindness (IAPB). The world sight day is now jointly coordinated by the IAPB and the WHO and is celebrated on the second Thursday of October every year.

OCTOBER 13 is the World Sight Day and the theme this year is 'Stronger Together'. The theme aptly signifies how different components – researchers in optics, patients, opticians, optometrists, orthoptists, ophthalmologists and allied workers – work together to appreciate, utilize, and advance the world of eye and eye care.

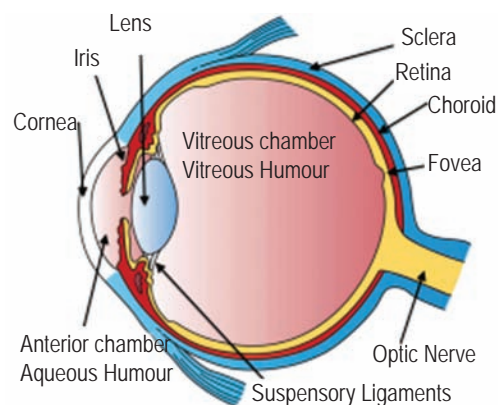
The eye is an interesting organ – a marvel of biological adaptation. Along with the brain it makes a complete processing system consisting of a camera, a filter, an aperture controller and an image sensor. The eye-brain system performs the acts of seeing by first forming the image of the object being seen and then by interpreting this image.

An eye sees just as a camera does – a highly sophisticated video camera. The eyelids act as the camera shutter. The compound lens formed by the cornea, a transparent structure in the front portion

of the eye, and the crystalline eye lens, form the focusing system of the camera. Iris, the coloured, ring-shaped membrane behind the cornea, acts like a diaphragm. The choroid helps in forming the darkened interior of the camera and the retina acts as a photographic film.

A fluid called the aqueous humour, which fills the space between cornea and iris, helps to maintain the cornea's optical shape by gentle internal pressure. A fluid called vitreous humour that fills the space between the lens and the retina helps to keep the retina in place.

The normal human eye can distinguish about 10 million colours and can easily adapt to the illumination levels of day light, which is about 100 million times more than that of the night light. However, the human eye also has several limitations.



Limitations of eye also arise due to age or other factors that inhibit its normal functioning. One of the most common limitations is the inability to focus light properly on the retina, known as refractive error or refraction error (Fig. 1). While some people have myopia or nearsightedness, others suffer from hyperopia or hypermetropia or farsightedness.



CAPABILITIES AND LIMITATIONS OF THE HUMAN EYE

Range and field of view	The farthest range that can be seen is considered to be infinity and the nearest range at which an object can be brought into sharp focus is approximately 25 cm. The field of view, combined for both eyes, is about 130°-135° vertical and about 200° horizontal.
Visible wavelength range	Cornea is transparent to wavelengths in the range 2950 A to 6000 A and the crystalline lens is transparent to 3500 A to 6000 A. Thus, wavelengths in the range 3500 A to 6000 A reach the retina. The eye is most sensitive to the yellow-green light with wavelength ~ 5500 A
Persistence of vision	0.1 sec
Optical power	Total power = +58 Diopter out of which +43 Diopter is contributed by cornea and +15 Diopter is contributed by the crystalline lens
Resolution	Angular resolution is about 1 minute or 0.02 degree, which corresponds to 0.3 m at a 1 km distance. The number of pixels is about 130 million.
Data Rate	500,000 bits per second without colour or around 600,000 bits per second including colour
Photon Energy Range	Energies less than few photons per sec upto 1015 photons per sec corresponding to bright sunlight
Bandwidth	A 2006 University of Pennsylvania study calculated the approximate bandwidth of information transmission of the human retina to be about 8960 kilobits per second.

Advancements in optical science and optical technology in the recent past have enabled eye care specialists to arrive at better and quicker solutions to detect eye limitations.

Detecting Eye Limitations

The typical kit for eye examination consists of equipments for objective examination such as a slit lamp, autorefractometer, retinoscope and ophthalmoscope and equipments for subjective examination such as Snellen chart and trial set.

The slit lamp uses a high-intensity light to examine the eye structures in detail, enabling anatomical diagnoses about cataract, conjunctivitis, changes in corneal curvature, corneal thickness, location of a foreign body, etc.

An autorefractometer is a computerised machine that facilitates an objective measurement of refractive error and prescription for glasses. The patient is asked to look at the picture inside the machine with one eye and the picture is moved in and out of focus and readings are taken by the machine to determine when the image is on the retina. The machine takes several readings and averages them to form a prescription. This method is particularly useful for examining patients who cannot communicate like young children and those with disabilities.

A Retinoscope provides a more accurate estimation of refractive error than autorefraction. It shines a beam of light into the patient's eye and the reflection (reflex) off the patient's retina is observed. Retinoscopy is particularly useful for

patients who are unable to undergo a subjective refraction test.

Ophthalmoscopy and fundus photography are also used for examination of the fundus – the interior surface of the eye opposite the lens. In fundus photography a photograph of the fundus is captured using a fundus camera that generally consists of a microscope attached to a flash enabled camera.

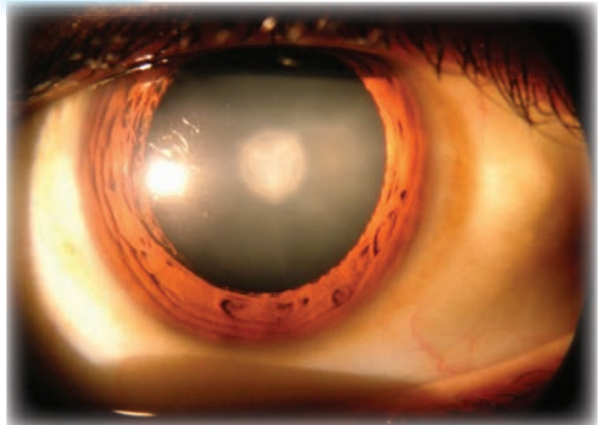
Examinations through equipments are followed by subjective examinations in which the examiner asks the patient about their vision by using lenses of progressively higher or weaker powers from a trial set. Generally, the term 'visual acuity' (VA), which means acuteness or clearness of vision, is used in this type of examination.

The Snellen chart (Fig. 6) is commonly used for subjective examination. It is based on the fact that the resolution of the human eye is 1 min. VA is recorded as a fraction where the numerator is the distance from which a person can resolve



Eye examination with the help of a slit lamp

Below: Cataract revealed in a slit lamp examination





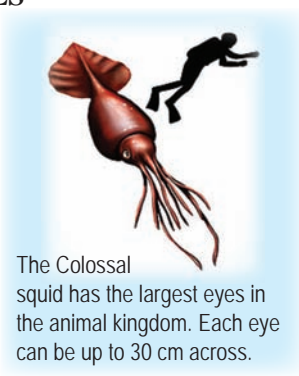
ANIMAL EYES



The tarsier, a nocturnal primate has the largest eyes relative to body size among mammals. Each eye weighs more than its brain.



The Leaf-tailed gecko can see up to 350 times better than humans in dim light!



The Colossal squid has the largest eyes in the animal kingdom. Each eye can be up to 30 cm across.



Eyes of dragonfly are so big that they cover almost the entire head.



Mantis shrimp have the most complex eyesight of any animal known.



The 'four eyed fish' has only two eyes! Each eye is divided in two that facilitates the fish to see both above and below the waterline. The upper half is adapted to vision in air and the lower half to underwater vision. Although both halves use the same lens they differ in their thickness and curve to make them suitable for vision in air and water.

a pair of objects and the denominator is the distance from which a person with normal eyesight would be able to resolve this pair of objects.

The examination is done by keeping a distance of 6 meter (or 20 feet) between the patient and the Snellen chart as this distance is essentially infinity from an optical perspective. Thus, the numerator is always 6 meter (or 20 feet). VA of 6 / 6 (or 20 / 20) is thus considered as normal. VA of 20 / 40 means a person is able to see details from 20 feet the same as a person with normal eyesight would see it from 40 feet, that is, half the normal acuity.

Similarly, 20/10 means twice the normal acuity.

A phoropter is an instrument containing different lenses used to measure the refractive error for determining the patient's eyeglass prescription. Typically, the patient is asked to look through a phoropter at an eye chart placed at optical infinity (20 feet or 6 metres), then at near (16 inches or 40 centimetres) for individuals needing reading glasses. The lenses are then changed and the patient is asked for feedback on the lenses that give the best vision.



Retinoscopy



An autorefractometer

Overcoming Eye Limitations

Eye limitations can be overcome either with the help of glasses or contact lenses or surgical procedures. While myopia can be easily corrected with the use of a concave lens, both hyperopia and presbyopia can be corrected with the help of appropriate convex lenses. Astigmatism can be corrected by refracting light more in one meridian than the other using a cylindrical lens.

A lensmeter is generally used to verify whether the lenses are made as per the prescription of the specialist. It is also used to properly orient and mark uncut lenses, and to confirm the correct mounting of lenses in spectacle frames.

Single vision lenses have a single power and can correct for only one

Ophthalmoscopy and Fundus Photography



Ophthalmoscopy



Fundus Camera



Fundus Photograph of Retina



SEEING THROUGH THE EYE OF HISTORY



Indian surgeon Sushruta wrote Sushruta Samhita in about 800 BC, which describes several ophthalmological surgical instruments and techniques. He has been described as the first cataract surgeon.



Ibn al-Haytham (Alhazen) an Arab scientist, mathematician and astronomer dealt extensively with the anatomy of the eye in his Book of Optics (1021).



In 1604, Johannes Kepler, a German mathematician and astronomer, published the first correct explanation of how presbyopia and myopia can be corrected using lenses. He also explained how the retina creates vision.



Willebrord Snell, a Dutch astronomer and mathematician, found the mathematical law of refraction in 1621.



Around 1784, Benjamin Franklin, an American scientist, is believed to have invented bifocals.



Around 1806, Georg Beer, an Austrian ophthalmologist and leader of the First Viennese School of Medicine, introduced a flap operation for treatment of cataracts.



Thomas Young, an English polymath and physician, made notable scientific contributions to the fields of vision and light and discovered the disability of astigmatism. In 1825, the British astronomer, George Airy designed the first lenses for correcting Astigmatism.



In 1834, Gottfried Treviranus, a German naturalist and botanist, discovered rods and cones.



In 1851, Hermann von Helmholtz, a German polymath, physician and physicist revolutionised the field of ophthalmology with the invention of the ophthalmoscope. He is known for his mathematics of the eye, theories of vision and research on the visual perception of space and color vision.



In 1862, Herman Snellen, a Dutch ophthalmologist, introduced the Snellen chart to study visual acuity.



Charles Schepens, a Belgian ophthalmologist, regarded as "the father of modern retinal surgery" invented the binocular indirect ophthalmoscope. The Schepens Eye Research Institute founded by him in 1950 is the largest independent eye research organisation in the United States.



In 1980, Rangaswamy Srinivasan, a physical chemist with IBM, discovered that an excimer laser could etch living tissue with precision and with no thermal damage to the surrounding area that contributed to the development of LASIK surgery.

According to the WHO (2010), 285 million people in the world are visually impaired, of whom 246 million people have low vision and 39 million are blind.

E	1	20/200
F P	2	20/100
T O Z	3	20/70
L P E D	4	20/50
P E C F D	5	20/40
E D F C Z P	6	20/30
F E L O P Z D	7	20/25
D E F P O T E C	8	20/20
L E F O D P C T	9	
F D P L T C E O	10	
F E Z O L C F T D	11	

Snellen Chart

distance. A bifocal lens has two optical powers; the upper part of the lens is generally used for distance vision, while the lower one for near vision. Bifocals allow people with presbyopia to see clearly at distance and near without the need to remove the glasses, which would be required with single vision lenses. Progressive or varifocal lenses having variable optical powers provide a smooth transition from distance correction to near correction allowing clear vision at all distances.

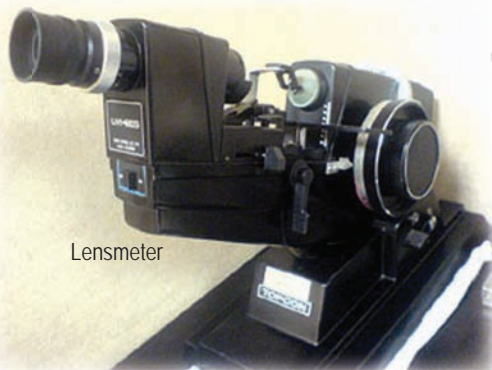
Cataract can be corrected by a surgical procedure in which the natural lens is removed and an artificial lens is implanted in its place. If treated early it is possible to slow or stop the progression of glaucoma with medication, laser treatment, or surgery. These treatments work towards decreasing the eye pressure.

Phoropter



Lensmeter and Different Types of Lenses

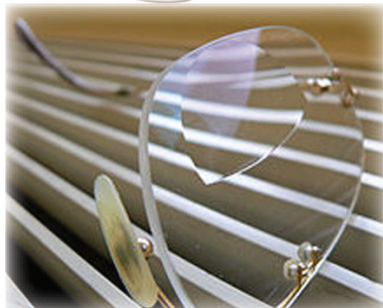
Snellen Chart



Lensmeter



Single vision lens



Bifocal lens



The limitations of myopia, hypermetropia, and astigmatism can also be overcome using a surgical procedure called LASIK (Laser-Assisted in situ Keratomileusis). In this surgery an ophthalmologist uses an excimer laser to reshape the eye's cornea in order to improve visual acuity. The LASIK procedure involves creating a thin flap on the eye, folding it to enable remodeling of the tissue beneath with a laser and repositioning the flap. The laser vaporises the layers of tissue of thickness of the order of tens of micrometers in a finely controlled manner.

PLAYERS IN THE WORLD OF EYE

Ophthalmologists deal with the anatomy, physiology and diseases and surgery of the eye and areas surrounding the eye, such as the lacrimal system and eyelids. Ophthalmology literally means "the science of eyes".

Optometrists deal with measurements of the eye. They diagnose common disorders as well as refractive vision correction. They are trained to prescribe and fit lenses to improve vision, and in some countries are trained to diagnose and treat various eye diseases.

Orthoptists are eye care professionals who specialise in the diagnosis and management of binocular vision abnormalities and specific pediatric disorders, in particular strabismus (squint), a condition in which the eyes are not properly aligned with each other.

Ocularists are specialists in the fabrication and fitting of ocular prostheses for people who have lost eyes due to trauma or illness. Opticians are specialists in the fitting and fabrication of ophthalmic lenses, spectacles, contact lenses, low vision aids and ocular prosthetics.

Stronger Together

The eye has fascinated scientists and significant insights have been revealed through the contributions from several fields ranging from basic optics to advanced laser technology. A peep into the knowledge world of eye from a historical viewpoint is presented in Table 4.

There are several players and components that contribute to the world of the eye such as lens makers, lens designers, lens grinders and lens cutters.

Given the importance of vision to the quality of life, professionals related to eye care often derive satisfaction from restoring or improving the patient's eye sight. Optometry is among one of the best 10 professions in US and UK. However, the eye care professionals and facilities are much shorter compared to what the world needs especially among the underdeveloped and developing countries. According to the WHO (2010), 285 million people in the world are visually impaired, of whom 246 million people have low vision and 39 million are blind.

However, up to 80% of blindness is curable or preventable with proper mobilization of resources. Age-related conditions leading to blindness such as cataract, refractive error and glaucoma can be easily and cheaply cured or their effects can be delayed or reduced if treated in time. According to WHO, about 80 percent of the world's blind people are aged over 50 years and about 90 percent of blind people live in low-income countries having poor eye care facilities. The Global

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Action Plan 2014-2019 sets itself a Global Target of a "Reduction in prevalence of avoidable visual impairment by 25% by 2019" (from the baseline prevalence in 2010).

India is home to the world's largest number of blind people, estimated to be over 15 million and the number is estimated to rise up to 31.6 million by 2020. The problem is compounded by the acute shortage of optometrists. In 2010 it was estimated that India needed 115,000 optometrists; whereas India had approximately 9000 optometrists (4-year trained) and 40,000 eye care personnel (2-year trained).

According to Ajeet Bhardwaj, the past president of the Asia Pacific Optometrists Organisation, "For India, it is vital that ophthalmologists focus on surgeries and optometrists take charge of primary eye care refractive errors like presbyopia, contact lenses, low-vision aids and vision therapies. This is how most developed countries managed to control and eliminate avoidable blindness."

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