# 7. LENSES

**Prepared By : Dr. P. W. MATTE**

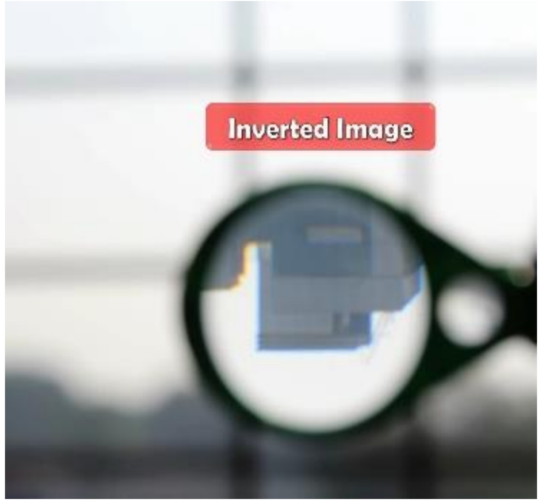


CLASS
10th

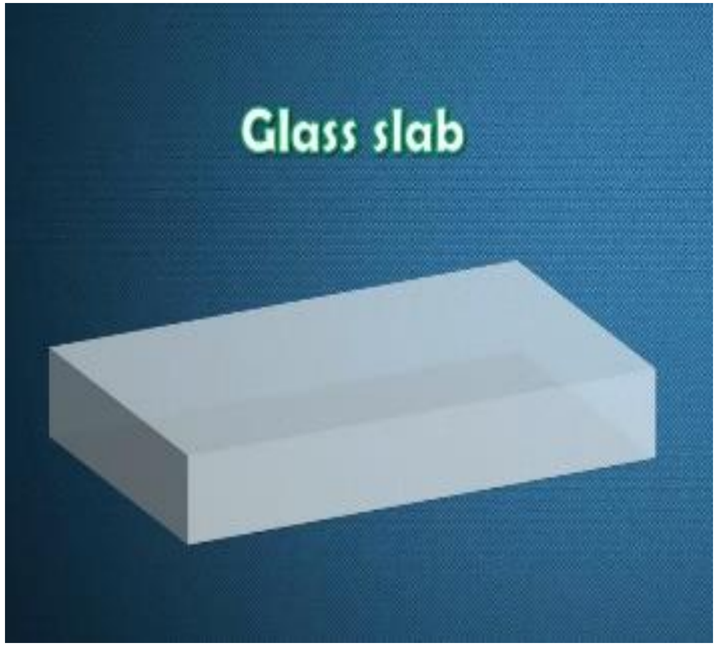
**SCIENCE & TECHNOLOGY**
**Part : I**

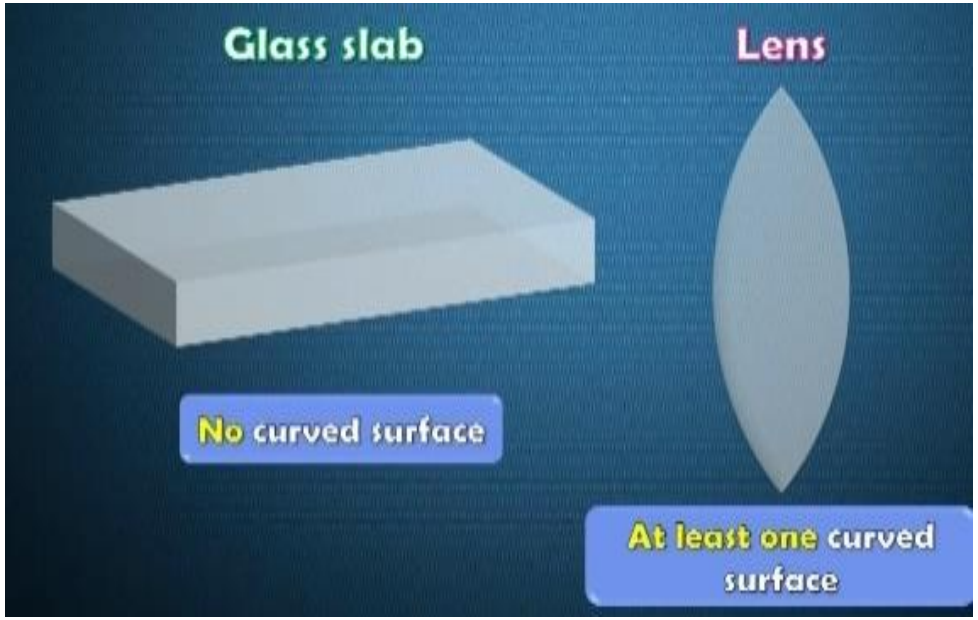
You must have seen lenses used in day-to-day life.

Some examples

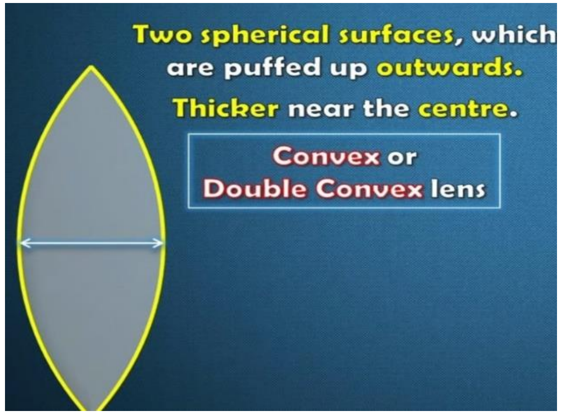


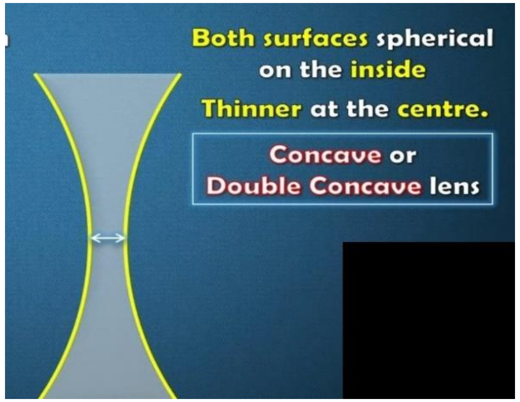


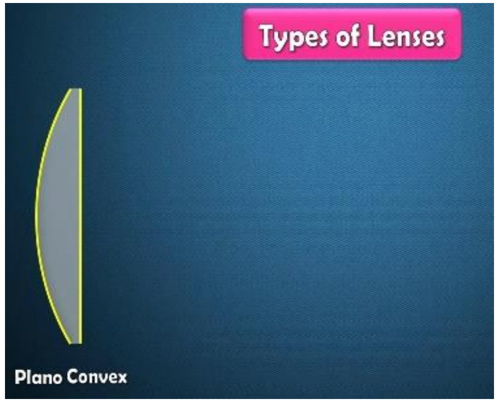

Glass slab

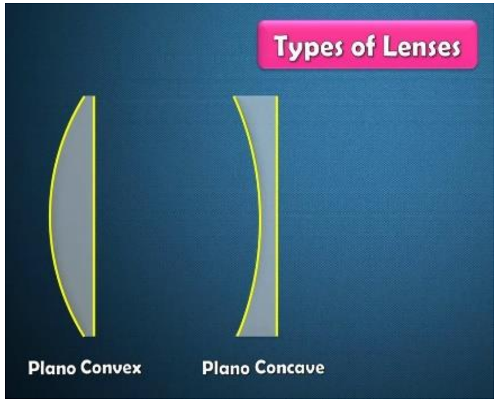

Glass slab
Lens
No curved surface
At least one curved surface

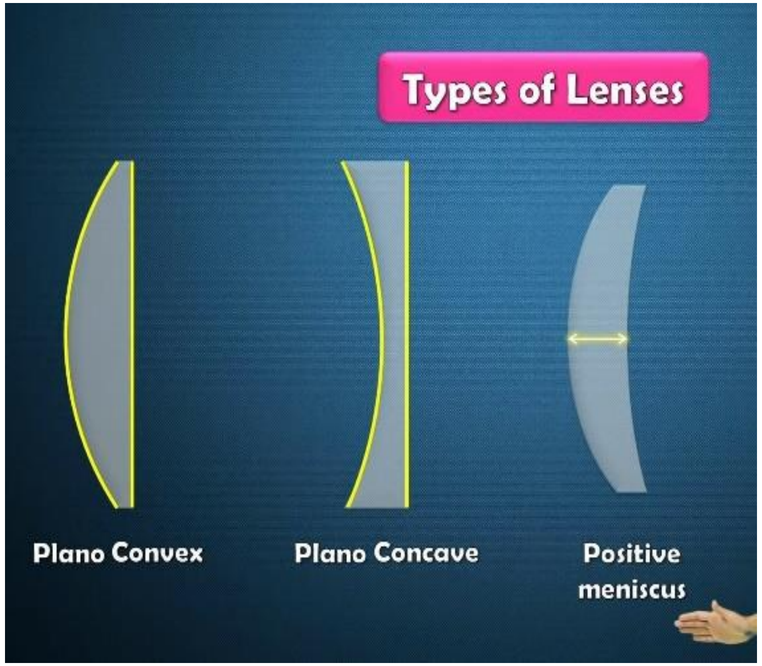
# TYPES OF LENSES

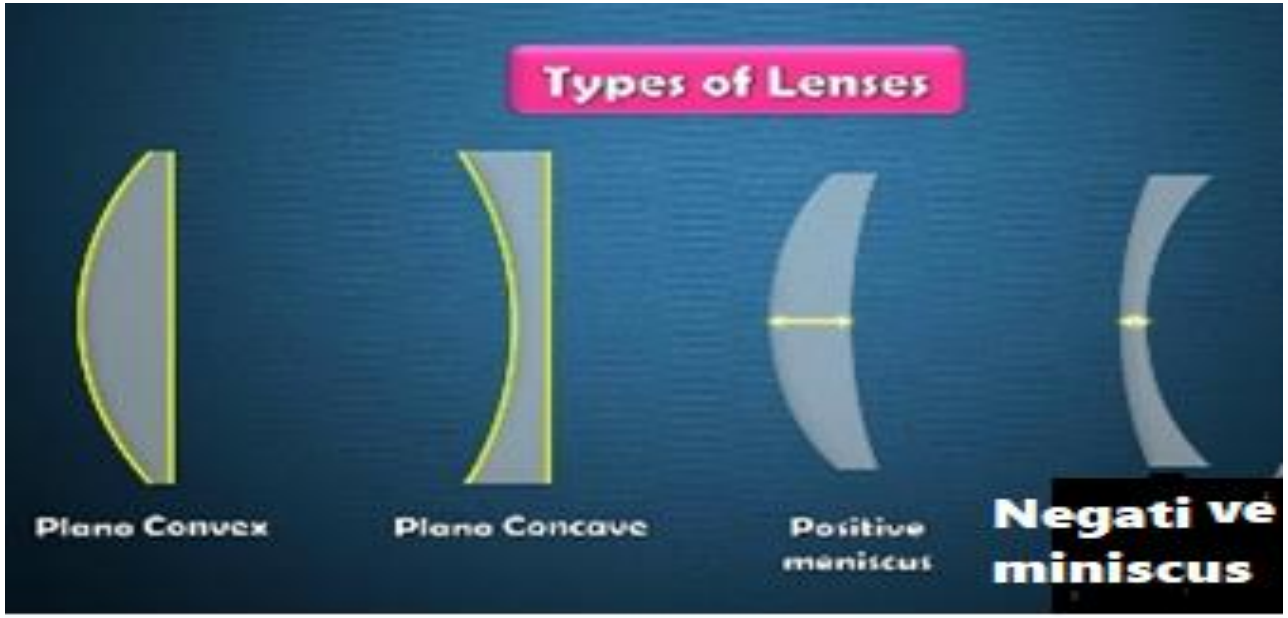


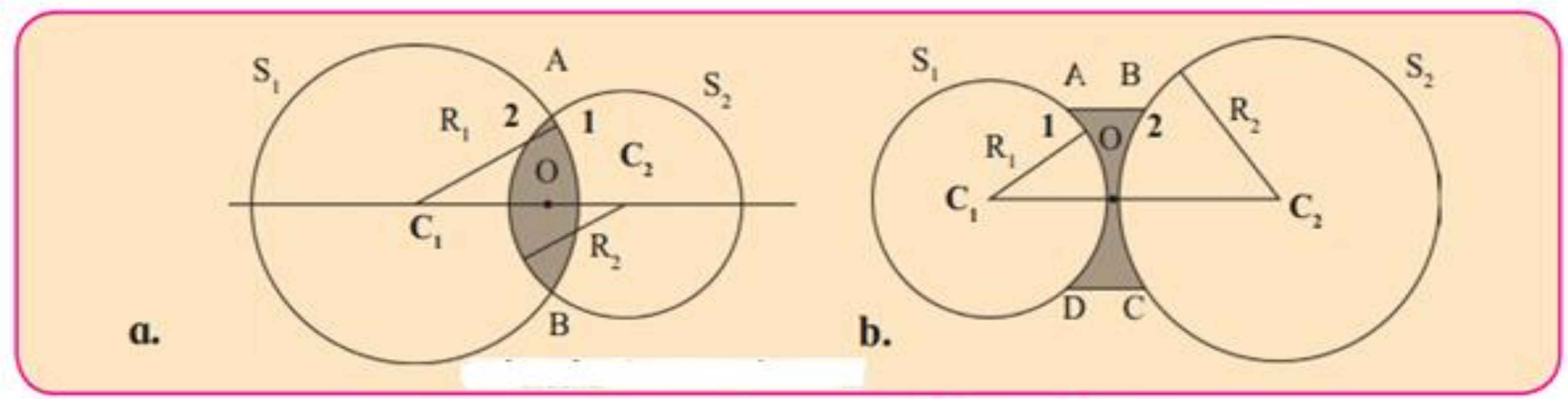



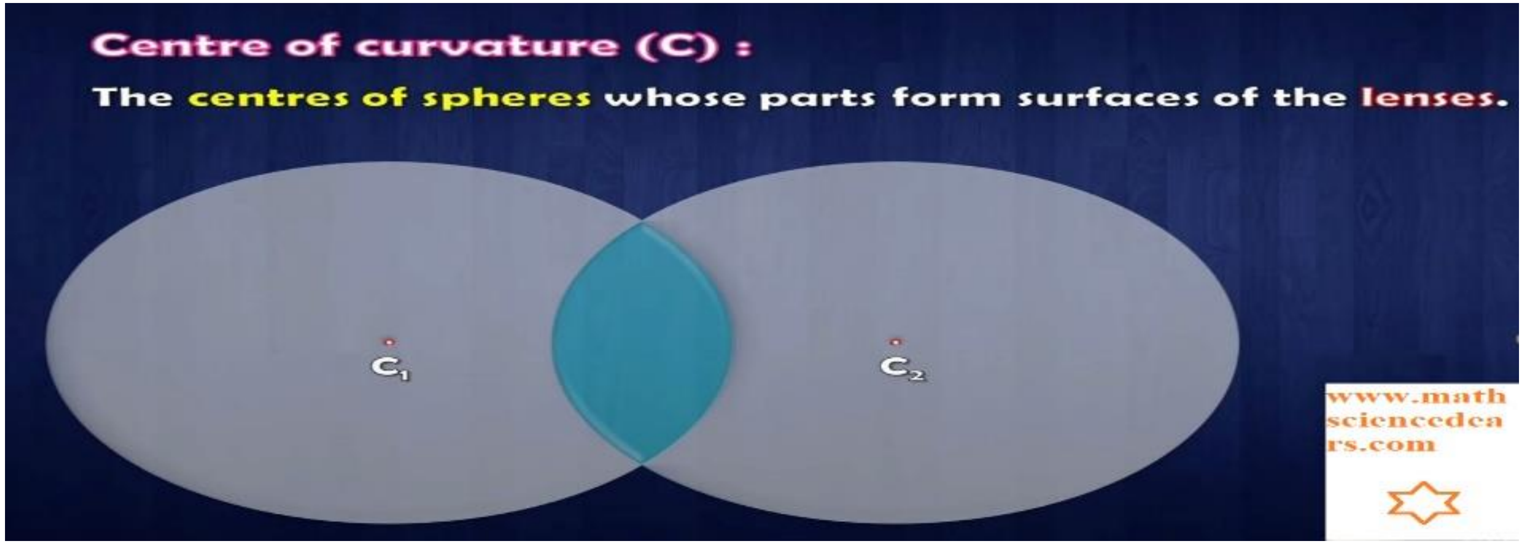



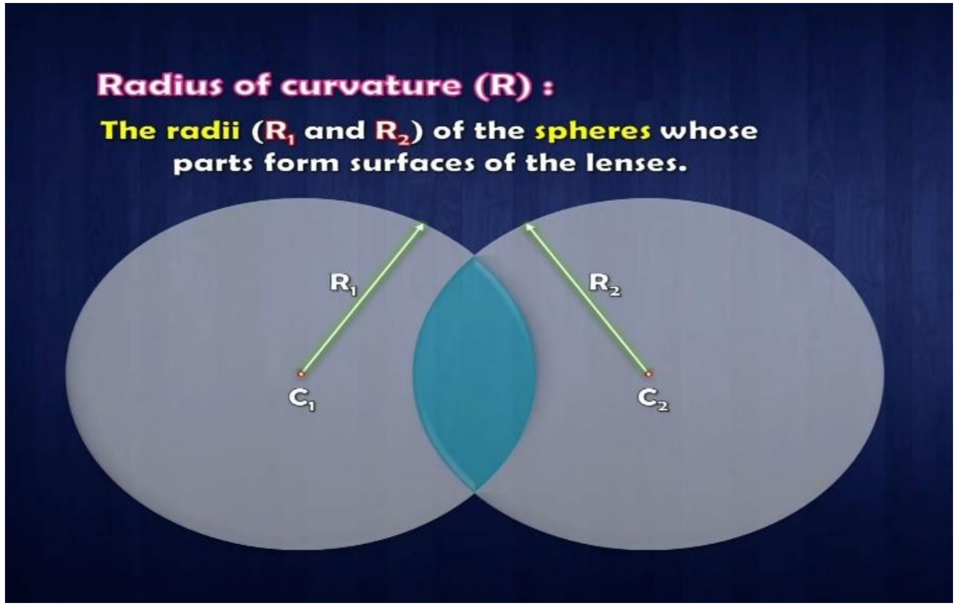
The cross-sections of convex and concave lenses are shown in parts a and b of the figure.

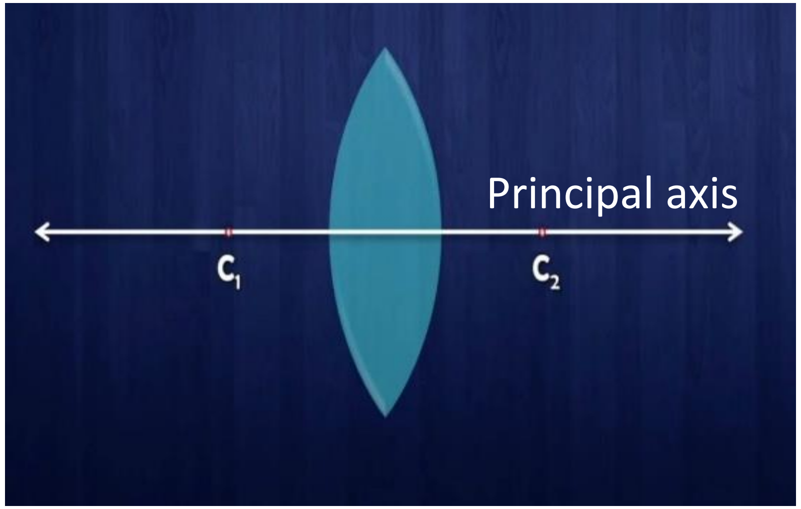


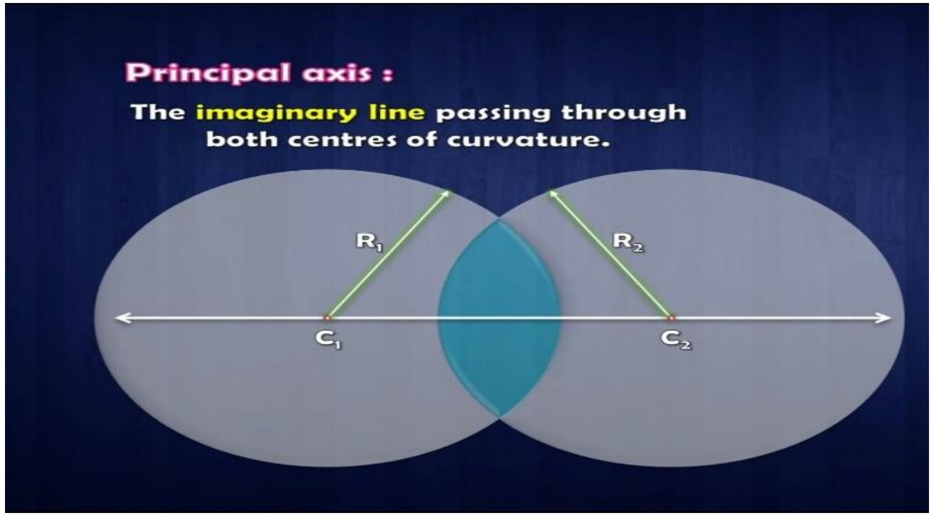

Cross-sections of convex and concave lenses.

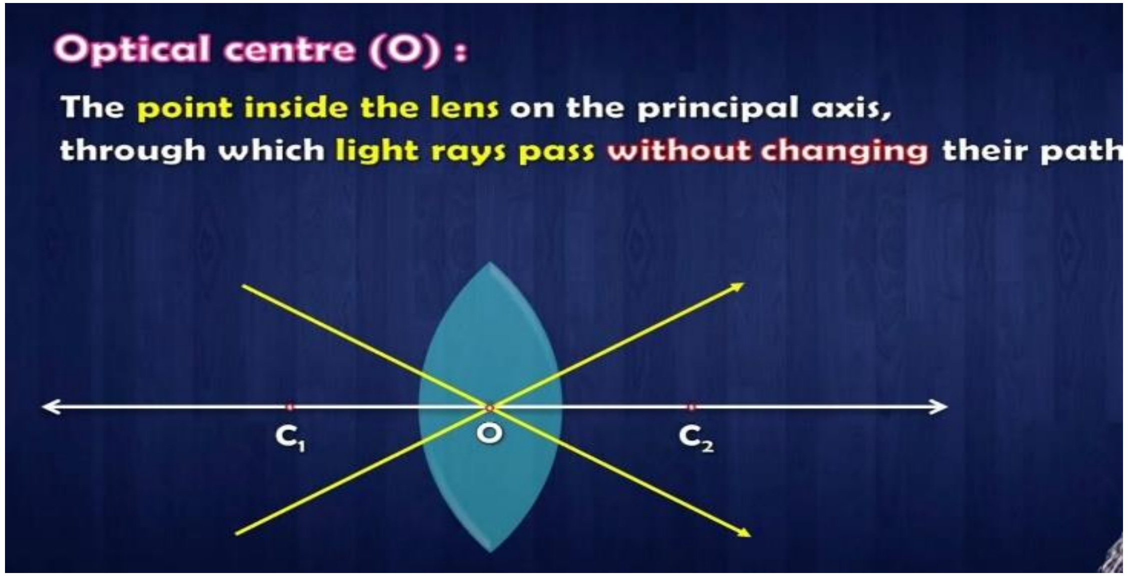
# Centre of Curvature (C) :

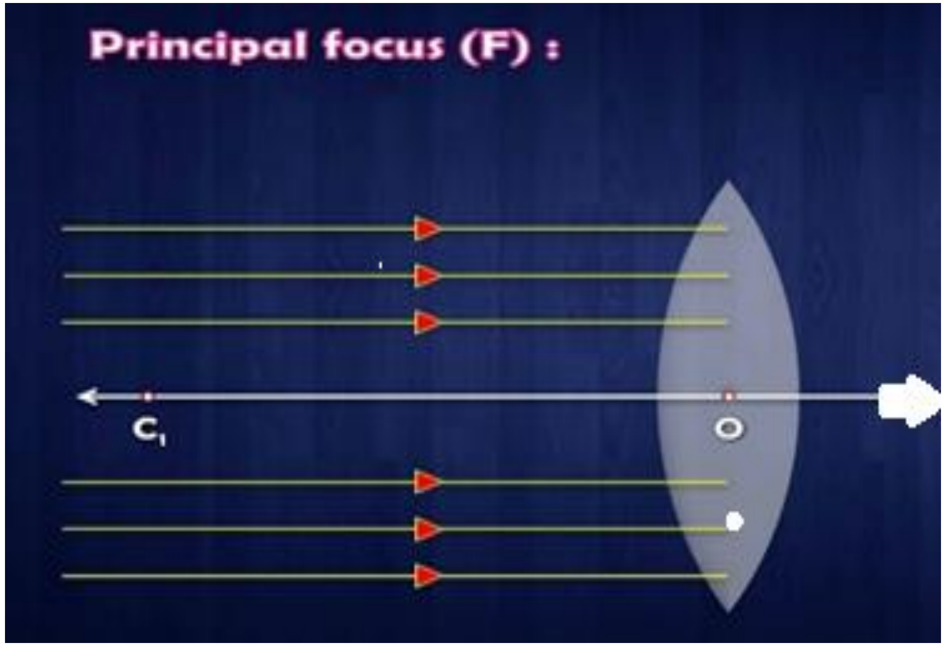


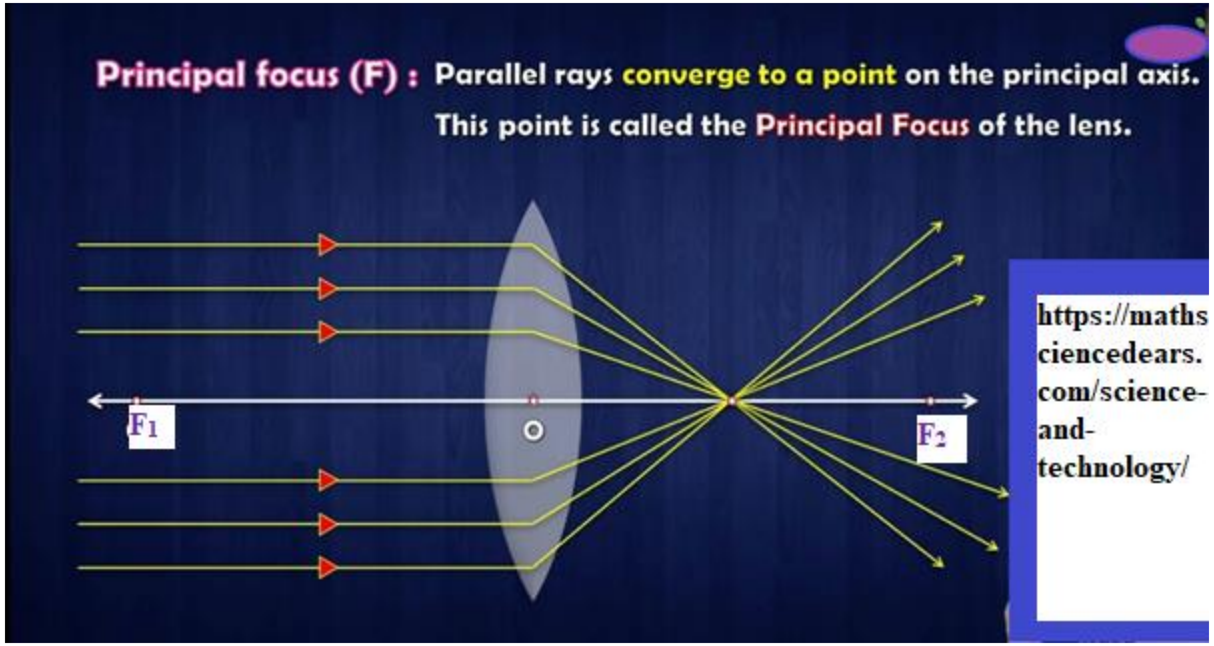

Radius of curvature (R) :
The radii ($R_1$ and $R_2$) of the spheres whose parts form surfaces of the lenses.
$R_1$
$R_2$
$C_1$
$C_2$


Principal axis
$C_1$
$C_2$


Principal axis :
The imaginary line passing through both centres of curvature.
$R_1$
$R_2$
$C_1$
$C_2$


Optical centre (O) :
The point inside the lens on the principal axis, through which light rays pass without changing their path
$C_1$
O
$C_2$

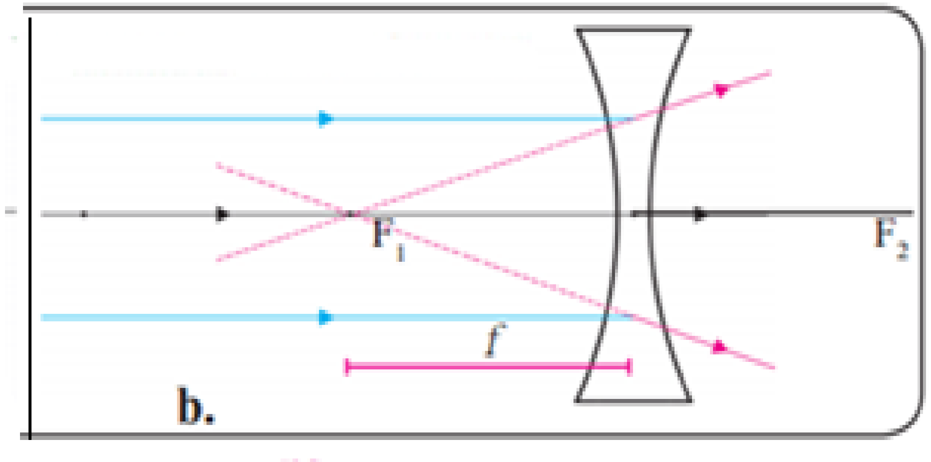



## Principal Focus (F) :

Light rays parallel to the principal axis falling on a convex lens come together i.e. get focused at a point on the principal axis. This point is called the **principal focus (F) of the lens.** So this type of lens is called a converging lens.

As shown in figure **$F_1$ $F_2$ are the principal foci of the convex lens.**




Rays traveling parallel to the principal axis of **a concave lens diverge after refraction** in such a way that they appear to be coming out of a point on the principal axis. This **point** is called the **principal focus** of the **concave lens.**

As shown in figure $\mathbf{F_1}$ $\mathbf{F_2}$ are the principal foci of the **concave lens.**

Light rays parallel to the principal axis falling on a concave lens go away from one another (diverge) after refraction. So this type of lens is called **a divergent lens.**

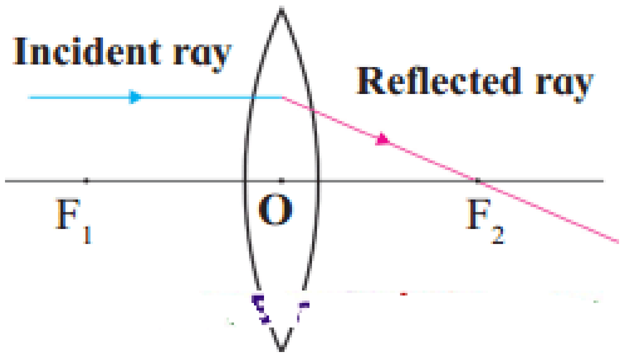
# •Ray Diagram for Refraction :

## Focal Length (f) :

The distance between the optical centre and the principal focus of a lens is called its focal length.

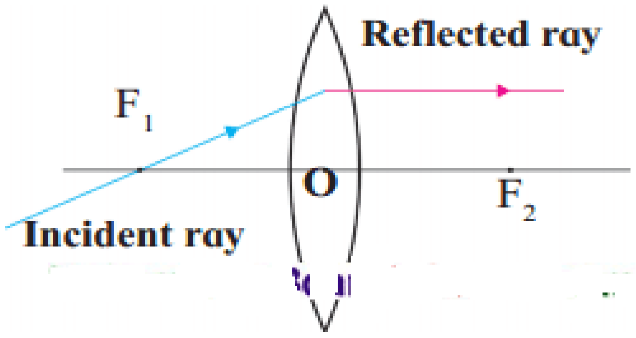
### Images Formed by Convex Lenses

**Rule 1 :**



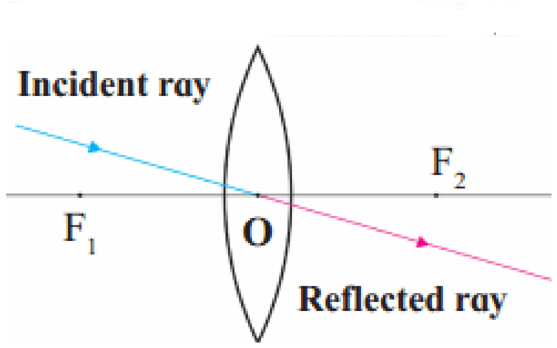

When the incident ray is parallel to the **principal axis**, the refracted ray passes through the **principal focus.**

**Rule 2 :**

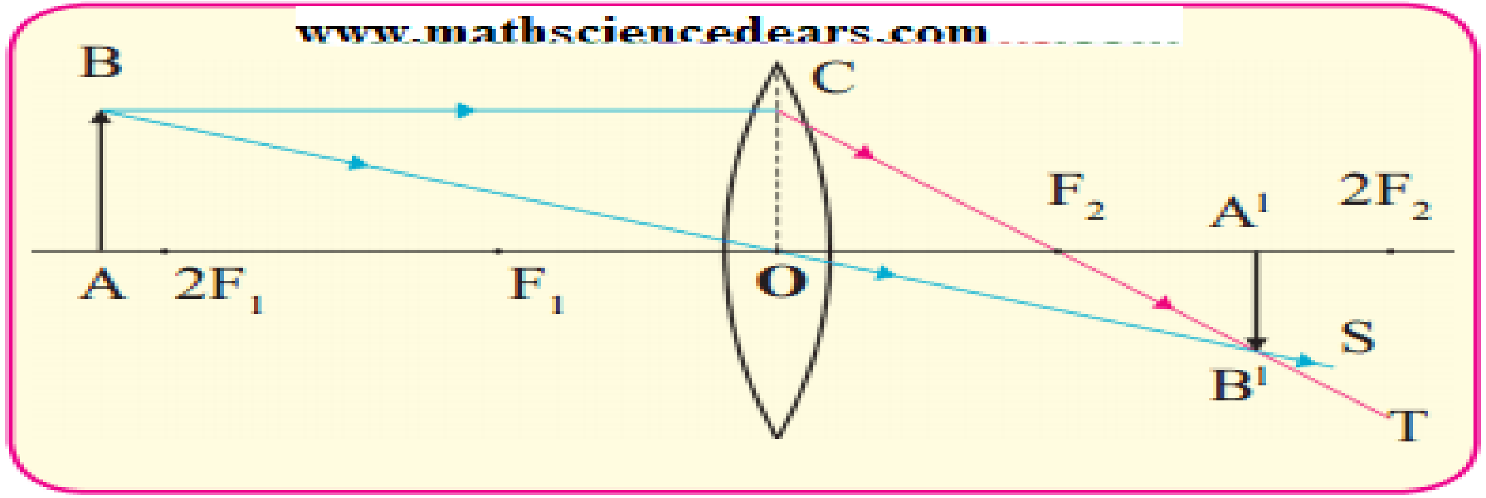



When the incident ray passes through the **principal focus**, the refracted ray is paparallel to the principal axis.

**Rule 3 :**




When the incident ray passes through the **optical centre** of the lens, it passes without changing its direction.



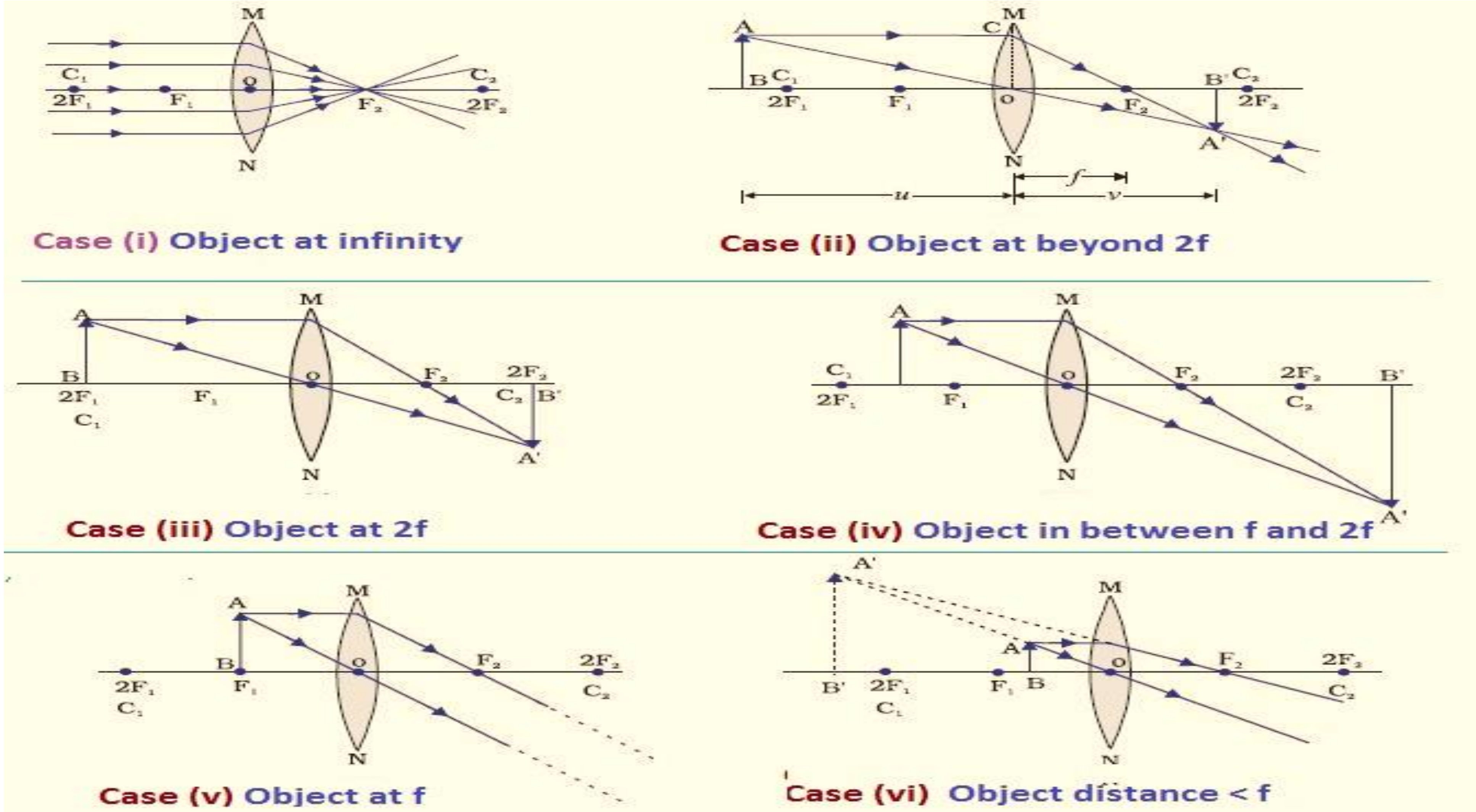

Real image formed by a convex lens

As A is situated on the principal axis, its image will also be located along the principal axis at A’, vertically above B’. Thus, A’B’ will be the image of AB formed by the lens. So we learn that if an object is placed beyond $2F_1$, the image is formed between $F_2$ and $2F_2$. It is **real and inverted and its size is smaller than that of the object.**

•Images are formed by convex lenses for different positions of the object.

| Position of the Object | Position of the Image | Size of the Image | Nature of the Image |
|---|---|---|---|
| 1. At infinity | At focus $F_2$ | Point Image | Real and Inverted |
| 2. Beyond $2F_1$ | Between $F_2$ and $2F_2$ | Smaller | Real and Inverted |
| 3. At $2F_1$ | At $2F_2$ | Same Size | Real and Inverted |
| 4. Between $F_1$ and $2F_1$ | Beyond $2F_2$ | Larger | Real and Inverted |
| 5. At focus $F_1$ | At infinity | Very Large | Real and Inverted |
| 6. Between $F_1$ and O | On the same side of the lens as the object | Very Large | Virtual and Erect |

# Images formed by Convex Lenses



Case (i) Object at infinity

Case (ii) Object at beyond 2f

Case (iii) Object at 2f

Case (iv) Object in between f and 2f

Case (v) Object at f

Case (vi) Object distance < f

## Images formed by Concave Lenses

We can obtain the images obtained by concave lenses using the following rules.

**•When the incident ray is parallel to the principal axis, the refracted ray when extended backward, passes through the focus.**

**•When the incident ray passes through the focus, the refracted ray is parallel to the principal axis.**

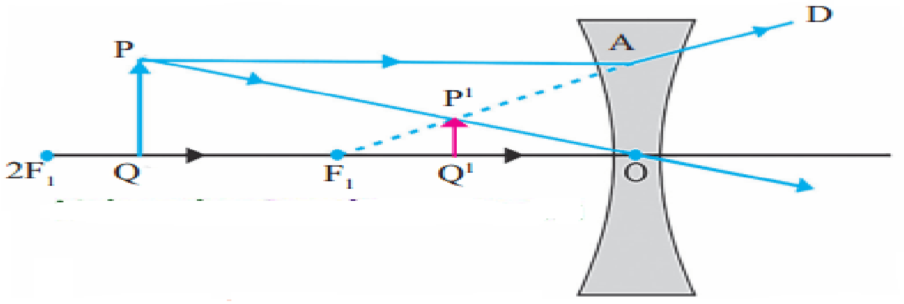
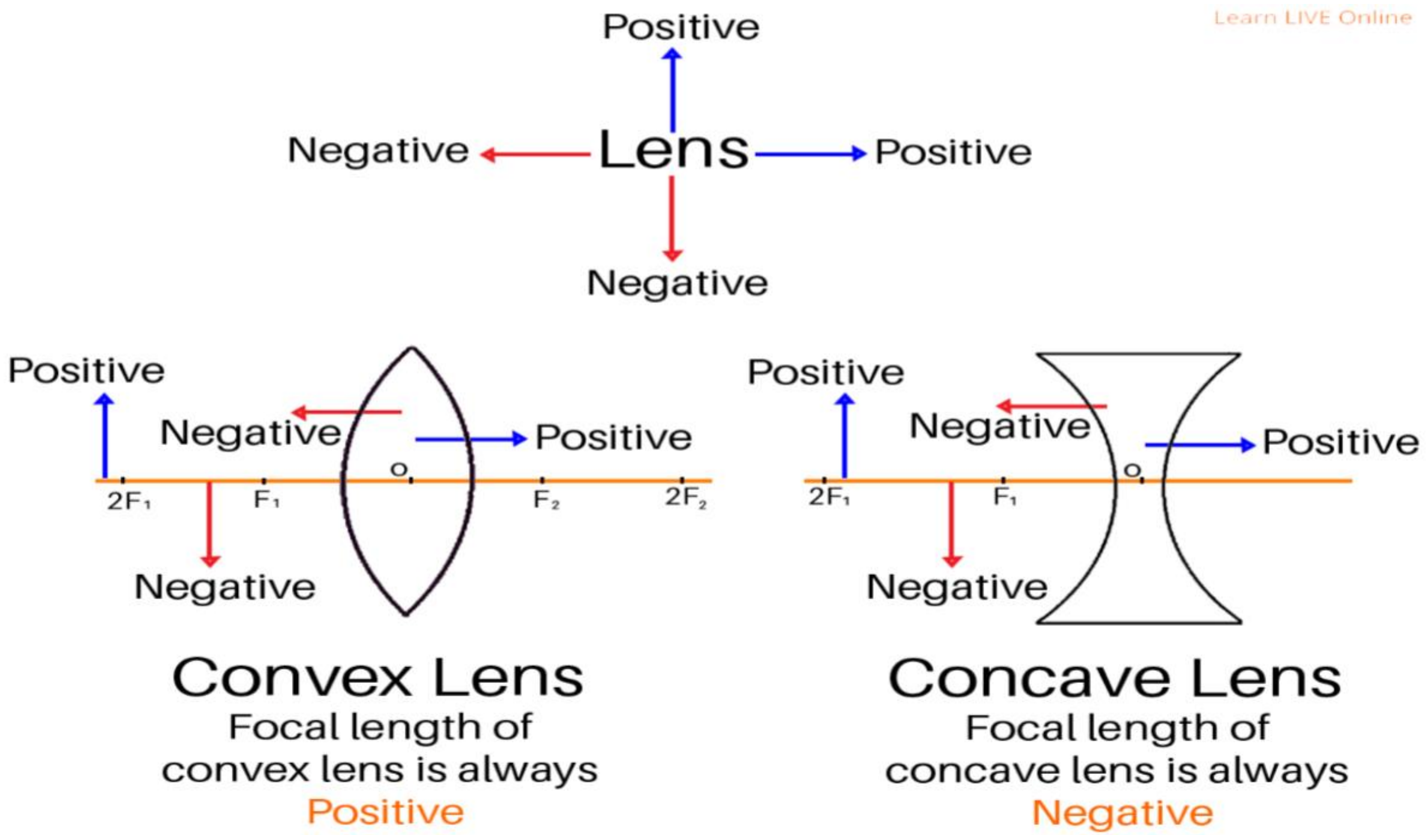



Image formed by a concave lens

As point Q is on the principal axis, its image is formed along the axis at the point $Q_1$ directly below $P_1$. Thus, $P_1Q_1$ is the image of PQ. The image formed by a concave lens is **always virtual, erect, and smaller than the object.**

| Position of the Object | Position of the Image | Size of the Image | Nature of the Image |
|---|---|---|---|
| 1. At infinity | On the first focus $F_1$ | Point Image | Virtual and Erect |
| 2. Anywhere between optical centre O and infinity | Between the optical centre and focus $F_1$ | Small | Virtual and Erect |

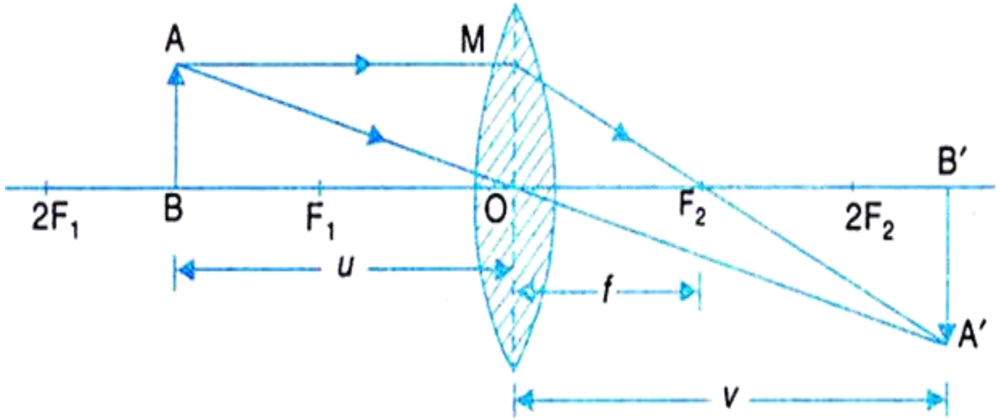
## Sign Convention



## Lens Formula

The formula showing the relation between the distance of the object (u), the distance of the image (v), and the focal length (f) is called the lens formula. It is given below.

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$




## ➢ Magnification (M)

The magnification due to a lens is the ratio of the height of the image ($h_2$) to the object's height ($h_1$).

**Magnification =** $\dfrac{\textbf{Height of the Image}}{\textbf{Height of the Object}}$ i.e. $M = \dfrac{h2}{h2}$ ............ (1)

The magnification due to a lens is also related to the distance of the object (u) and that of the image (v) from the lens.

Magnification = $\dfrac{\textbf{Distance of the Image}}{\textbf{Distance of the object}}$ i.e. $\mathbf{M} = \dfrac{\mathbf{v}}{\mathbf{u}}$ ............ (2)

# Power of a Lens

The capacity of a lens to converge or diverge incident rays is called its power (P). The power of a lens depends on its focal length. Power is the inverse of its focal length (f); f is expressed in meters. The unit of the power of a lens is Dioptre (D).

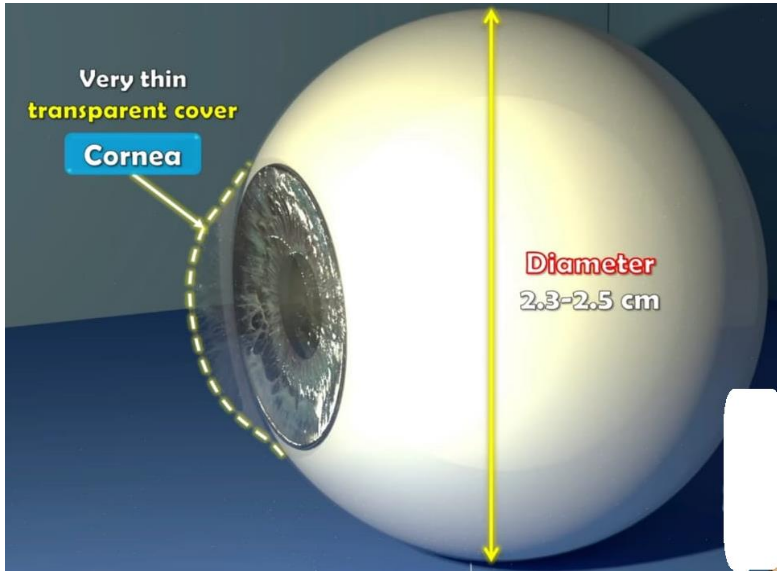
$$P = \frac{1}{f(m)} \qquad 1 \text{ Dioptre} = P = \frac{1}{1(m)}$$

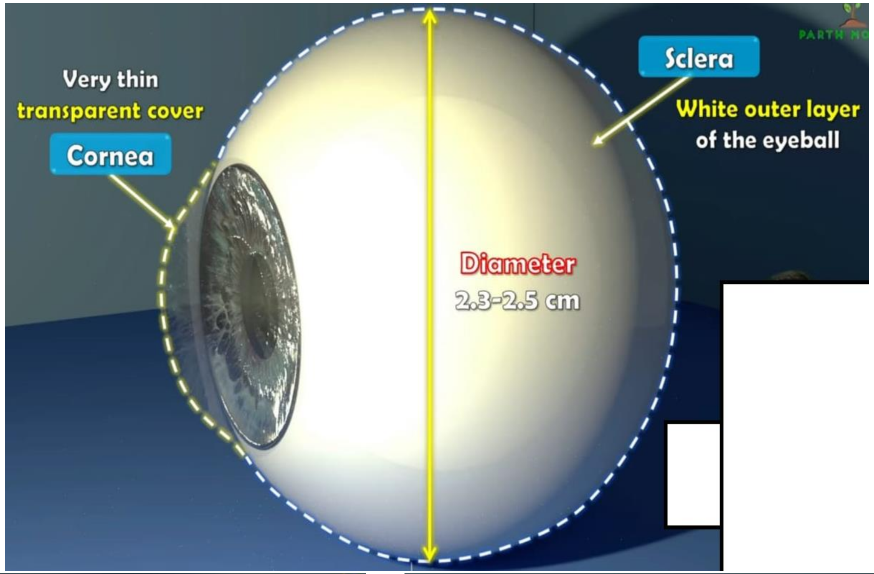
# Combination of Lenses

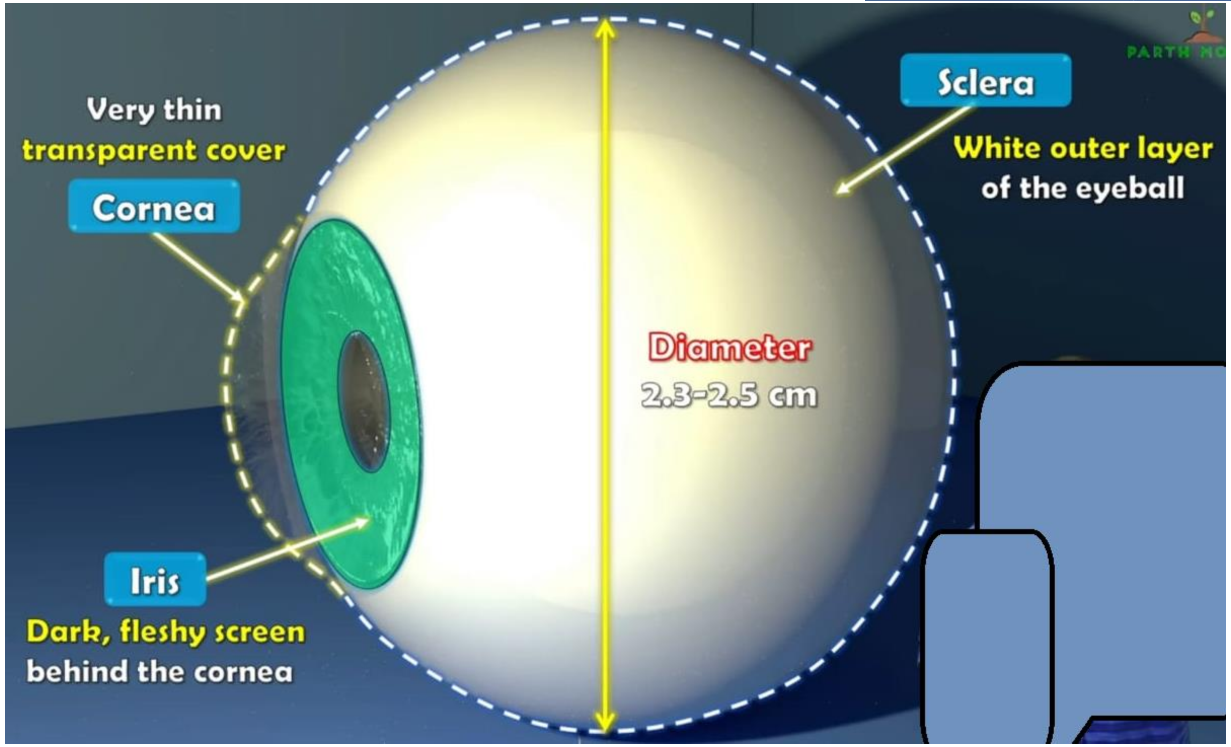
If two lenses with focal lengths $f_1$ and $f_2$ are kept in contact with each other, the combination has an effective focal length given by

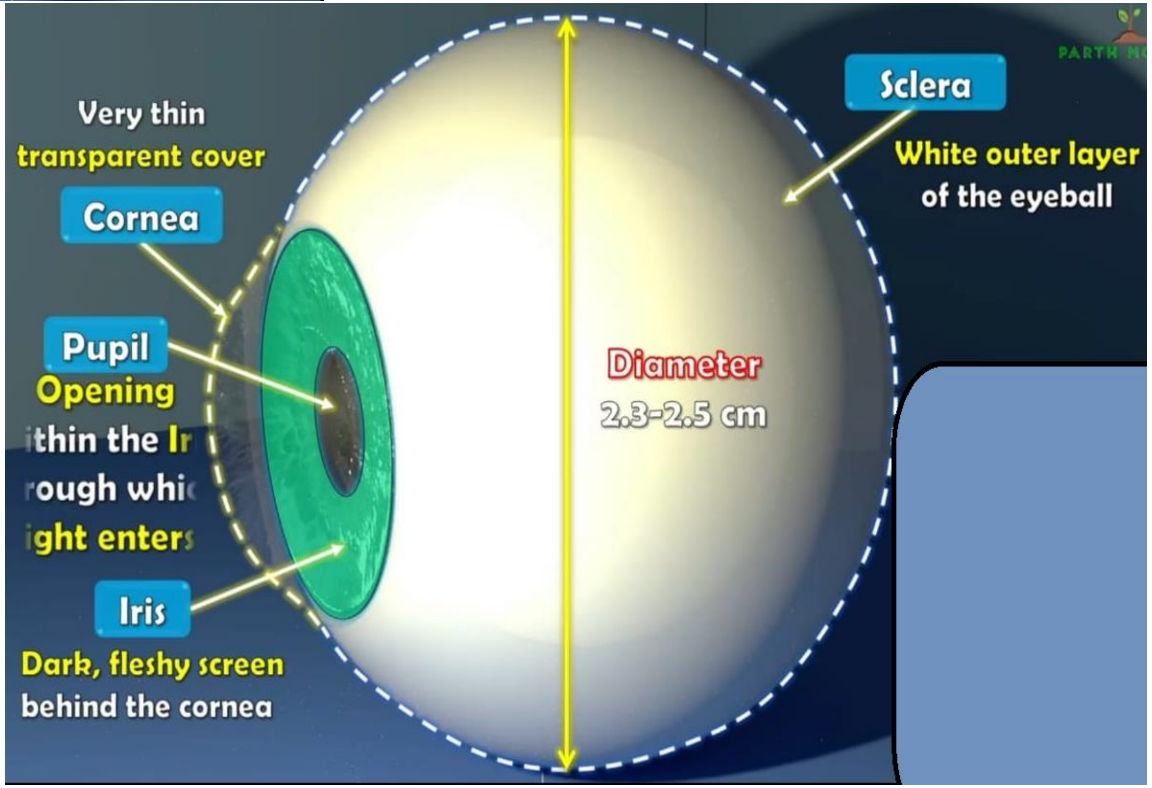
$$\frac{1}{f} = \frac{1}{f1} + \frac{1}{f2}$$

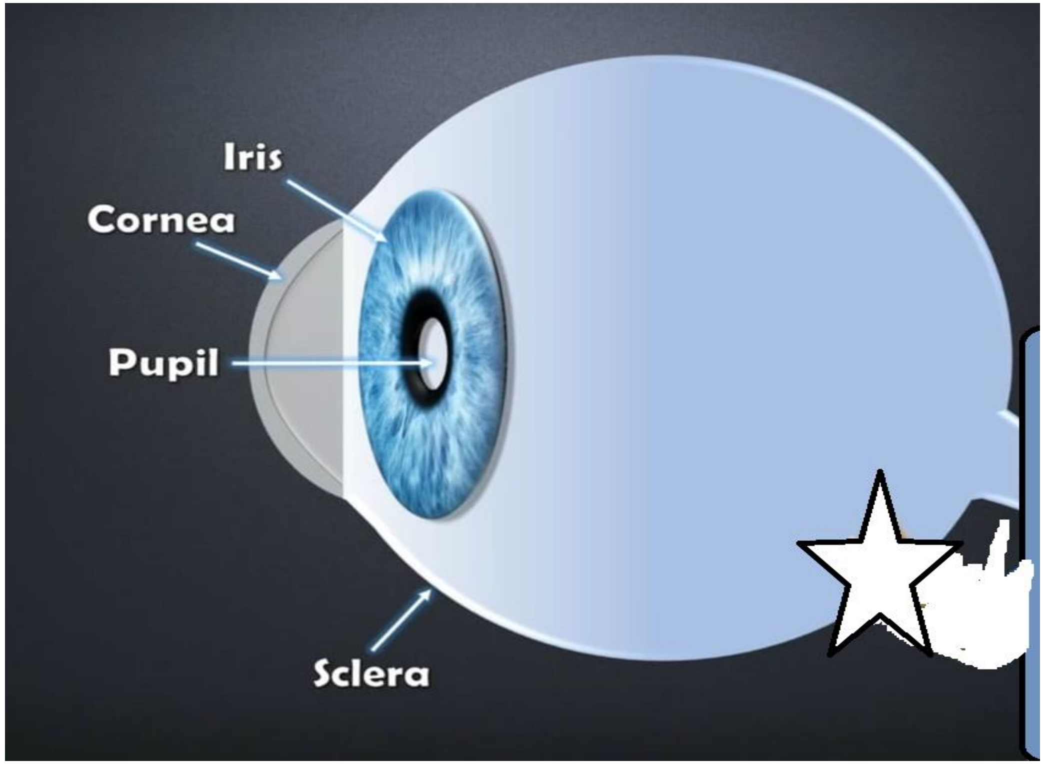
If the powers of the two lenses are $P_1$ and $P_2$ then the effective power of their combination **is $P e = P_1 + P_2$.**
Thus, when two lenses are kept touching each other. the power of the combined lens is equal to the sum of their powers.

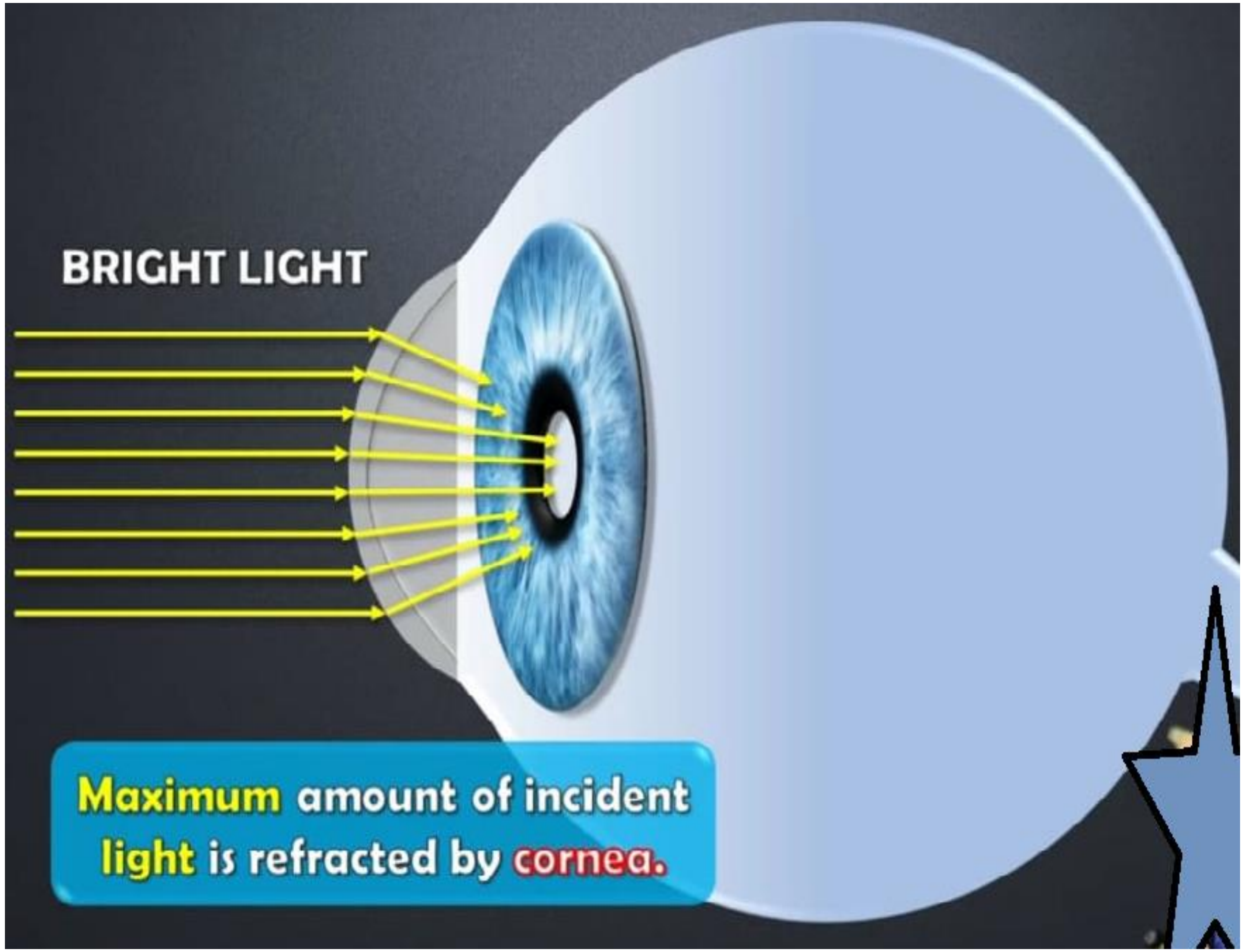

Very thin
transparent cover
Cornea
Diameter
2.3-2.5 cm

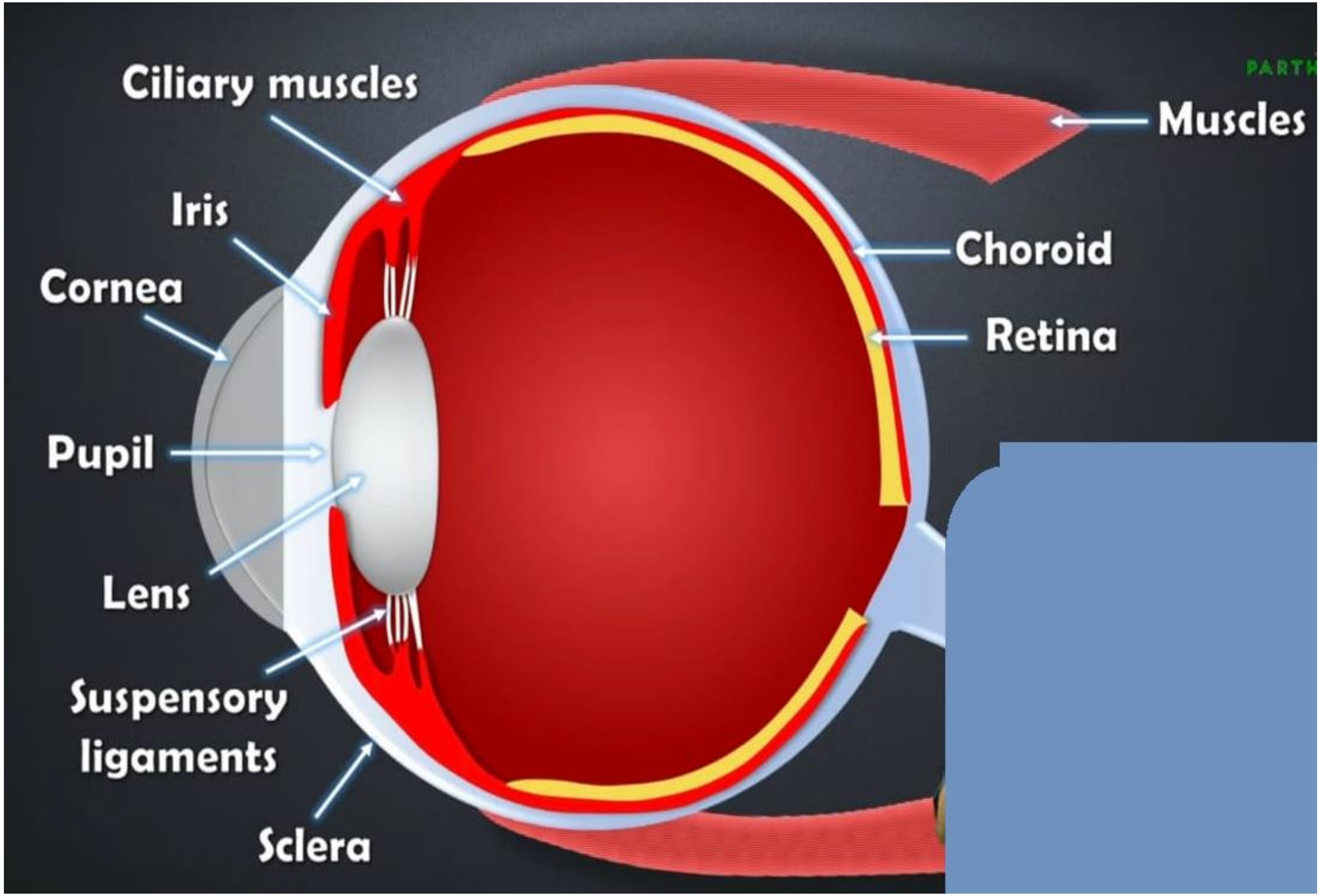

Very thin
transparent cover
Cornea
Sclera
White outer layer
of the eyeball
Diameter
2.3-2.5 cm

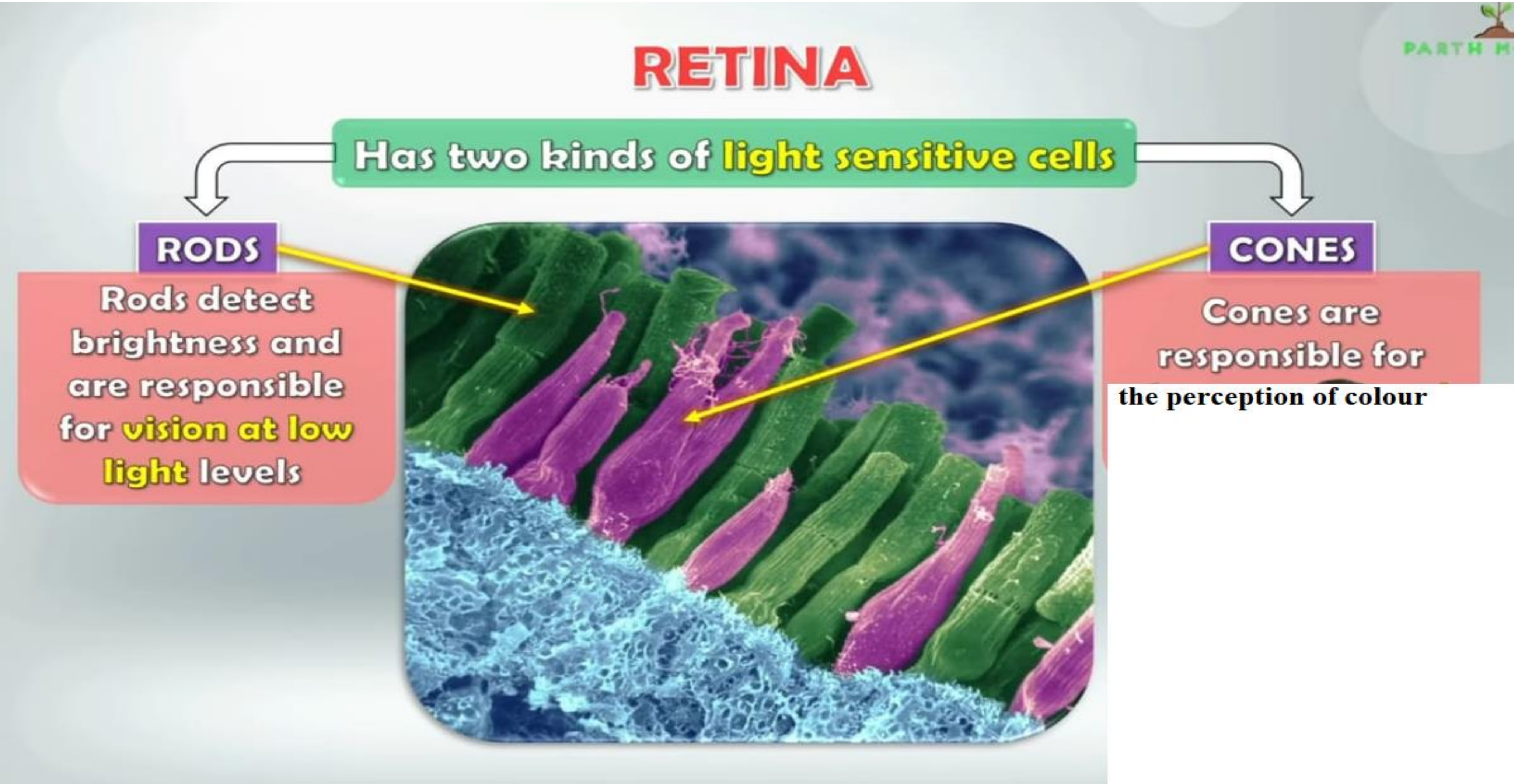

Very thin
transparent cover
Cornea
Sclera
White outer layer
of the eyeball
Diameter
2.3-2.5 cm
Iris
Dark, fleshy screen
behind the cornea


Very thin
transparent cover
Cornea
Sclera
White outer layer
of the eyeball
Pupil
Opening
ithin the Ir
ough whi
ight enter
Diameter
2.3-2.5 cm
Iris
Dark, fleshy screen
behind the cornea


Iris
Cornea
Pupil
Sclera


BRIGHT LIGHT
Maximum amount of incident light is refracted by cornea.


Ciliary muscles
Muscles
Iris
Choroid
Cornea
Retina
Pupil
Lens
Suspensory
ligaments
Sclera


RETINA
Has two kinds of light sensitive cells
RODS
Rods detect brightness and are responsible for vision at low light levels
CONES
Cones are responsible for
the perception of colour

# THANK YOU

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MATH-SCIENCE DEARS

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