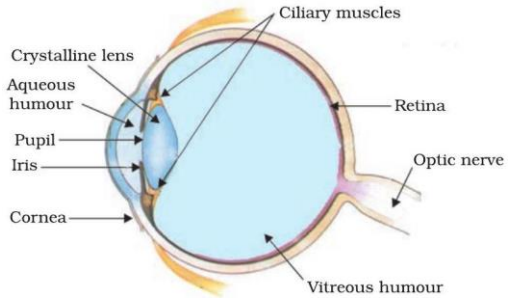
# Chapter 10: The Human Eye and the Colourful World - Detailed Notes (NCERT Class 10 Science)

This chapter explores one of the most vital sense organs, the human eye, and then delves into fascinating natural phenomena related to light and its dispersion.

## I. The Human Eye

The human eye is like a natural camera that enables us to see the world around us.




### A. Structure of the Human Eye:

The human eye is roughly spherical, with a diameter of about 2.3 cm. Key parts include:

1. **Cornea:**
    - The transparent, bulging front surface of the eyeball.
    - It acts as a thin membrane and forms the main light-refracting surface.
    - Most of the refraction of light entering the eye occurs at the outer surface of the cornea.
2. **Iris:**
    - A dark, muscular diaphragm located behind the cornea.
    - Controls the size of the pupil.
    - Its colour gives the eye its distinctive colour (e.g., blue eyes, brown eyes).
3. **Pupil:**
    - The black opening in the centre of the iris.
    - Regulates and controls the amount of light entering the eye.
    - In bright light, the iris contracts the pupil to reduce light entry. In dim light, the iris expands the pupil to allow more light in.
4. **Lens (Crystalline Lens):**
    - A transparent, biconvex structure located behind the pupil and iris.
    - It is made of a fibrous, jelly-like material.
    - Provides the finer adjustment of focal length required to focus objects at different distances on the retina.
    - Its curvature can be modified by ciliary muscles.
5. **Ciliary Muscles:**
    - Muscles attached to the eye lens.
    - They change the curvature (and thus the focal length) of the eye lens.
    - When they relax, the lens becomes thinner (focal length increases), for distant vision.

    - When they contract, the lens becomes thicker (focal length decreases), for nearby vision.
6. **Retina:**
    - The light-sensitive screen at the back of the eyeball.
    - It contains millions of light-sensitive cells:
        - **Rods:** Respond to the intensity of light (responsible for vision in dim light).
        - **Cones:** Respond to colour and bright light (responsible for colour vision and vision in bright light).
    - These cells convert light energy into electrical signals.
7. **Optic Nerve:**
    - A bundle of nerves originating from the retina.
    - Transmits the electrical signals (impulses) from the retina to the brain.
    - The brain interprets these signals, and we "see" the object.
    - **Blind Spot:** The point where the optic nerve leaves the eye; it has no sensory cells (rods or cones), so no vision is possible there.

**B. Working of the Human Eye:**

1. Light from an object enters the eye through the cornea.
2. It passes through the pupil (controlled by the iris to regulate light amount).
3. The light then passes through the eye lens.
4. The cornea and the eye lens converge the light rays to form a real, inverted, and diminished image on the retina.
5. The light-sensitive cells (rods and cones) on the retina detect this image and convert the light energy into electrical signals.
6. These electrical signals are sent to the brain via the optic nerve.
7. The brain interprets these signals and inverts the image, allowing us to perceive the object upright and as it is.

**C. Power of Accommodation:**

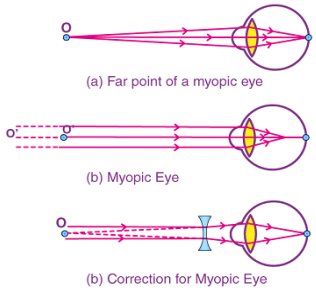
- The ability of the eye lens to adjust its focal length to clearly focus objects located at various distances on the retina.
- This is achieved by the action of the ciliary muscles, which change the curvature and thickness of the eye lens.
- **Near Point (Least Distance of Distinct Vision):** The closest distance at which an object can be seen clearly without strain. For a young adult with normal vision, it is about **25 cm**.
- **Far Point:** The farthest distance at which an object can be seen clearly. For a normal eye, the far point is at **infinity**.
- The range of vision for a normal eye is from 25 cm to infinity.

## II. Defects of Vision and Their Correction

Due to various reasons, the eye's power of accommodation can become defective.

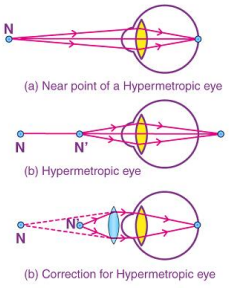
**A. Myopia (Near sightedness):**

- **Definition:** A person with myopia can see nearby objects clearly but cannot see distant objects distinctly.
- **Cause:**
    1. Excessive curvature of the eye lens (lens is too convergent).
    2. Elongation of the eyeball (image forms in front of the retina).
- **Correction:** Myopia is corrected by using a **concave lens** of appropriate power. A concave lens diverges the light rays slightly before they enter the eye, allowing the image to form correctly on the retina.




**B. Hyper metropia (Far sightedness):**

- **Definition:** A person with hypermetropia can see distant objects clearly but cannot see nearby objects distinctly.
- **Cause:**
    1. The focal length of the eye lens is too long (lens is not convergent enough).
    2. The eyeball is too short (image forms behind the retina).
- **Correction:** Hypermetropia is corrected by using a **convex lens** of appropriate power. A convex lens converges the light rays more, ensuring the image forms on the retina.




**C. Presbyopia:**

- **Definition:** The power of accommodation of the eye usually decreases with aging. People find it difficult to see nearby objects comfortably and distinctly.
- **Cause:**
    1. Gradual weakening of the ciliary muscles.
    2. Decreasing flexibility of the eye lens.
- **Correction:** Often requires **bifocal lenses**. The upper portion is a concave lens (for distant vision), and the lower portion is a convex lens (for near vision).

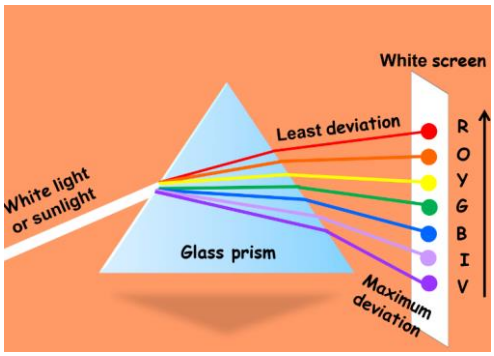
## III. Refraction of Light Through a Prism

### A. Prism:

- A transparent optical element with flat, polished surfaces that refract light.
- Typically has two triangular bases and three rectangular lateral surfaces.
- The angle between its two lateral faces is called the **angle of the prism (A)**.

### B. Refraction through a Prism:

- When a light ray passes through a prism, it deviates from its original path.
- The incident ray, refracted ray, and emergent ray are involved.
- The **angle of deviation (δ)** is the angle between the direction of the incident ray and the direction of the emergent ray.
- The base of the prism always bends the light towards it.




## IV. Dispersion of White Light by a Glass Prism

### A. Dispersion:

- The phenomenon of splitting of white light into its constituent colours (spectrum) when it passes through a transparent medium like a glass prism.
- **Cause:** Different colours of light travel at different speeds in a medium (except vacuum), leading to different refractive indices for different colours. This causes them to bend at different angles.
- **VIBGYOR:** The sequence of colours obtained is Violet, Indigo, Blue, Green, Yellow, Orange, and Red.
    - **Violet light** bends the most (shortest wavelength, largest deviation).
    - **Red light** bends the least (longest wavelength, smallest deviation).

### B. Recombination of Spectrum (Newton's Experiment):

- Sir Isaac Newton showed that if two identical prisms are placed side by side, one inverted relative to the other, the first prism disperses white light, and the second prism recombines the seven colours back into white light.
- This proved that white light is indeed composed of seven colours.

## V. Atmospheric Refraction

The refraction of light by the Earth's atmosphere is called atmospheric refraction. This phenomenon is responsible for several interesting observations.

**A. Twinkling of Stars:**

- **Cause:** The Earth's atmosphere has varying densities and temperatures, causing the refractive index to continuously fluctuate randomly.
- As starlight enters the atmosphere, it undergoes continuous refraction in different directions before reaching our eyes.
- This continuous change in the apparent position of the star (due to varying refraction) makes the starlight appear to flicker or "twinkle."
- Planets do not twinkle because they are much closer to Earth, appearing as extended sources of light. The total light received from them averages out the variations, so their apparent brightness remains relatively stable.

**B. Advance Sunrise and Delayed Sunset:**

- **Cause:** Atmospheric refraction.
- **Advance Sunrise:** The Sun is visible to us about **2 minutes before** it actually rises above the horizon. This is because the atmosphere refracts sunlight from below the horizon towards our eyes.
- **Delayed Sunset:** The Sun remains visible for about **2 minutes after** it has actually set below the horizon, due to the same reason.
- This phenomenon increases the duration of daytime by about 4 minutes.

## VI. Scattering of Light

**A. Scattering:**

- The phenomenon in which light rays are deflected in various directions when they strike tiny particles or molecules of a medium.
- The amount of scattering depends on the wavelength of light and the size of the scattering particles.

**B. Tyndall Effect:**

- The phenomenon of scattering of light by colloidal particles (or very fine suspended particles) in a medium.
- The path of the light beam becomes visible due to scattering.
- **Examples:**
    - Light beam entering a dusty room through a small hole becomes visible.
    - Sunlight passing through a canopy of a dense forest.

**C. Colour of the Sky:**

- **Cause:** Scattering of light by the fine particles (molecules of air) in the atmosphere.
- Blue light has a shorter wavelength and scatters much more strongly than red light (Rayleigh scattering, which states scattering is inversely proportional to the fourth power of wavelength).

- When sunlight passes through the atmosphere, the blue light is scattered in all directions. When we look at the sky, the scattered blue light enters our eyes, making the sky appear blue.

**D. Colour of the Sun at Sunrise and Sunset:**

- **Cause:** At sunrise and sunset, the sun's rays have to travel a much longer distance through the atmosphere to reach our eyes.
- Most of the shorter wavelength blue light and other shorter wavelength colours are scattered away by the atmosphere.
- The longer wavelength red and orange light, which scatter least, are able to reach our eyes.
- This makes the Sun and the sky around it appear red or orange.

**E. Why is Danger Signals are Red?**

- Red light has the longest wavelength among visible light.
- It is scattered the least by smoke, fog, and dust particles in the atmosphere.
- Therefore, red light can travel the longest distance without being significantly scattered, making it visible even in adverse weather conditions.