

# Unit 3 - Behind Sensations

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## Stimuli and Responses

The body responds to various changes happening inside and outside it. These changes are called stimuli.

Stimuli: The circumstances that lead to responses in living beings. They are divided into:

- **External Stimuli:** Examples include seeing a friend, hearing a loud sound, or heat.
- **Internal Stimuli:** Examples include hunger, thirst, or an increase in body temperature during disease.

## Receptors and Impulses

Stimuli are recognized by specialized cells or nerve endings called Sensory Receptors. These receptors produce electrical impulses in response to stimuli.

Key Terms:

- **Receptor Potential:** The initial electrical impulse produced in a receptor.
- **Action Potential:** Formed in the neurons associated with receptors when receptor potential is in higher concentration. Action potential travels through neurons as nerve impulses.

## Sensory Receptors and Senses

Senses are divided into general senses and special senses.

General Senses: Recognized by receptors in skin, muscles, joints, and internal organs (e.g., touch, pain, heat, pressure).

Special Senses: Recognized by receptors concentrated in specific organs (e.g., vision, hearing, taste, smell).

## The Eye: Structure and Protection

The eye is located in the eye socket (orbit) of the skull.

### Protective Parts:

- **Conjunctiva:** A membrane covering the anterior part of the eye (except the cornea). It protects and lubricates the eye.
- **Lacrimal Glands:** Produce tears to keep the surface moist, provide nutrients, and eliminate waste. Tears contain lysozyme, an enzyme that protects against infections.
- **Eyelids and Eyelashes:** Prevent dust and foreign particles from entering the eye.
- **Eye Muscles:** Help in the movement of the eye within the socket.

### Layers of the Eye

- **Sclera (Outer Layer):** Provides firmness and protection.  
Its transparent anterior part is the Cornea, which allows light to enter.

- **Choroid (Middle Layer):** Provides oxygen and nutrients. Contains the pigment Melanin, which gives color to the eye and absorbs UV rays. Includes the Iris (regulates pupil size) and Ciliary Muscles (adjusts lens curvature).
- **Retina (Inner Layer):** The layer where the image is formed.
  - Photoreceptor Cells:-
    - Rod Cells: These recognize objects in dim light and provide vision in shades of black and white.
    - Cone Cells: These provide vision in intense (bright) light and help in recognizing colors.
    - Bipolar Cell Layer: Transmits impulses from the photoreceptors to the ganglion cells.
    - Ganglion Cell Layer: Transmits impulses from the bipolar cells to the optic nerve.
 It also includes the Yellow Spot (macula) where cone cells are abundant and the Blind Spot where the optic nerve originates and vision is absent.

### Chambers and Fluids

- Aqueous Chamber: Between the cornea and lens. Contains watery aqueous humor, which maintains pressure and provides oxygen/nutrients.
- Vitreous Chamber: Between the lens and retina. Contains jelly-like vitreous humor, which maintains the shape of the eyeball.

### The Path of Light through the Eye

Cornea → Aqueous humor → Pupil → Lens → Vitreous humor → Retina

### Iris and Pupil

- The Iris is the part seen behind the cornea.
- At its centre is an aperture called the pupil.
- The normal size of the pupil is from 2 to 3 mm. By increasing the size of the pupil, it is possible to direct 16 times more light onto the retina than normal.
- The size of the pupil is regulated by two types of muscles in the iris: radial muscles and circular muscles.
- This regulation is essential for clear vision in dim light and to prevent retinal damage in intense light.

### Structure and Composition of the Lens

The lens is a critical refractive structure with three main parts:

- Capsule: An elastic membrane that encloses the lens.
- Lens fibres: Contained within the capsule.
- Epithelium: Located solely in the anterior part, between the lens fibres and the capsule. It continuously produces lens fibres throughout an individual's lifetime.

**Power of Accommodation:** The ability of the eye to focus images of both near and distant objects accurately on the retina by changing the curvature of the lens through ciliary muscle action.

Condition	Ciliary Muscles&Ligaments	Lens Curvature
Viewing Distant Objects	Ciliary muscles are relaxed; Ligaments are stretched	Curvature decreases (Lens becomes thin)
Viewing Near Objects	Ciliary muscles contract; Ligaments relax	Curvature increases (Lens becomes thick)

### Photoreceptors: Rods and Cones

The retina contains two types of photoreceptor cells: rod cells (approx. 9 crores) and cone cells (approx. 45 lakhs).

- Rod Cells: Contain the pigment Rhodopsin. Sensitive to dim light.
- Cone Cells: Contain the pigment Photopsin. Sensitive to intense light and responsible for color vision.

Common Components: Both pigments include a protein (Opsin) and Retinal (formed from Vitamin A).

### Mechanism of Vision: Light vs. Dark

#### In the Dark

- Photoreceptors continuously produce glutamate.
- On bipolar cells (sense light) are inactivated.
- Off bipolar cells (sense darkness) are activated.
- Off bipolar cells form impulses that reach the brain through the optic nerve, creating a sense of darkness.

#### In the Presence of Light

- Photoreceptors do not produce glutamate.
- On bipolar cells become active.
- Off bipolar cells become inactive.
- On bipolar cells form impulses that reach the brain through the optic nerve, creating a sense of vision.

## Colour Vision and Binocular Fusion

- There are three types of cone cells sensitive to primary colours: S-cones (blue/short), M-cones (green/medium), and L-cones (red/long).
- Stimulation of these in varying proportions creates the perception of different colours.
- Simultaneous stimulation of all three creates white light.
- Colour Blindness: Caused by defects in cone pigments. Red/green pigment genes are on the X chromosome; blue is on chromosome 7

## Binocular Fusion

Images from different angles reach the visual cortex. The brain combines these images (fusion) to provide 3D vision, depth perception, and distance calculation.

## Eye Diseases and Disorders

Disease/Disorder	Reason	Treatment/Remedy
Short-sightedness (Myopia)	Enlarged eyeball / focal length decreases	Concave lens / surgery
Long-sightedness (Hyperopia)	Shortened eyeball	Convex lens
Astigmatism	Irregular curvature of cornea/lens	Cylindrical lens
Cataract	Lens becomes opaque	Lens replacement surgery
Glaucoma	Increased pressure (reabsorption failure of aqueous humor)	Laser surgery/medication
Night blindness	Deficiency of Vitamin A	Vitamin A rich food
Xerophthalmia	Prolonged Vit A deficiency; cornea becomes opaque	Prevention via diet
Conjunctivitis	Infection in the conjunctiva	Medical treatment

## Eye Care and Ophthalmology

Protection: Wash eyes frequently with clean water; eat Vitamin A rich foods; manage screen time.

World Sight Day: Observed on the second Thursday of October.

Ophthalmology: Specialized branch dealing with diagnosis and treatment of eye diseases.

## Structure of the Ear

Main Part	Associated Parts
Outer Ear	Pinna, Auditory canal, Tympanum (Eardrum)
Middle Ear	Ear ossicles (Malleus, Incus, Stapes), Eustachian canal
Inner Ear	Cochlea, Vestibule, Semicircular canals

## Functions of Specific Parts

- Pinna: Directs sound waves into the auditory canal; helps identify sound direction; protects the auditory canal.
- Auditory Canal: Directs sound waves to the tympanum. Contains hair and wax/sebum (with disinfectant properties) to prevent dust and germs.
- Tympanum: A thin circular membrane (0.1 mm thick) that vibrates in accordance with sound waves.
- Ear Ossicles: Malleus, Incus, and Stapes. They amplify and transmit vibrations from the tympanum to the oval window of the inner ear.
- Eustachian Canal: A 4 cm long tube connecting the middle ear to the pharynx. It balances pressure on both sides of the tympanum.

## The Inner Ear: Cochlea and Hearing

- The cochlea is a snail-shell shaped structure with three chambers.
- The upper and lower chambers are filled with perilymph, while the middle chamber is filled with endolymph.
- The Organ of Corti, containing auditory receptors (hair cells), is situated on the basilar membrane.

## The Pathway of Hearing

**Pinna → Auditory canal → Tympanum → Malleus → Incus → Stapes → Oval window → Perilymph → Endolymph → Basilar membrane → Organ of Corti → Auditory nerve → Brain (Cerebrum)**

## Maintaining Body Balance

The vestibular system in the inner ear maintains body balance. It includes the three semicircular canals, the vestibule (utricle and saccule), and hair cells.

- Rotational Movement: Monitored by the semicircular canals. Endolymph movement stimulates hair cells in the canals.

- **Linear Movement:** Monitored by the utricle and saccule within the vestibule. Movement stimulates hair cells to generate impulses.
- **Coordination:** Impulses reach the cerebellum via the vestibular nerve. The cerebellum maintains balance by coordinating muscles.

## Olfaction (Sense of Smell)

Smell is perceived through olfactory receptors located in the mucus membrane of the nasal cavity. The process involves the following steps:

- Volatile olfactory particles enter the nasal cavity during breathing.
- These particles dissolve in the mucus produced by the mucus membrane.
- The dissolved particles stimulate millions of olfactory receptor neurons.
- Impulses are generated and travel through the olfactory nerve to the brain.
- The brain recognizes the smell, and the sense of smell is effected.

## Taste

Taste is detected by chemoreceptors located within taste buds on the papillae of the tongue. Each taste bud contains about 100 chemoreceptors with microvilli reaching minute pores.

- **Mechanism:** Substances giving rise to taste dissolve in saliva and stimulate the chemoreceptors.
- **Transmission:** Impulses reach the brain through the sensory nerves.  
Primary Tastes: Sweet, sour, salty, pungent (umami), bitter.

## Sensory Diversity in Organisms

Different organisms have evolved unique mechanisms to perceive their surroundings:

- **Amoeba/Bacteria:** Detects the presence of chemicals and moves accordingly.
- **Euglena:** The eyespot (stigma) helps to detect light and move towards it.
- **Insects:** The compound eye made up of Ommatidia. The Antenna helps detect smell and touch.
- **Bat:** Ears and special type of echo location organ helps in hunting and travelling.
- **Hawk:** Eyes with high vision; systems for long distance vision and detecting ultraviolet radiation.
- **Snake:** Jacobson's organ helps to detect smell.
- **Dog:** Highly sensitive olfactory receptors (300 million).
- **Elephant:** Largest number of olfactory genes (about 2000). Can detect water from 19 km using the trunk; can sense ground vibrations.