REFLEX ACTION AND REFLEX ARC

Reflex Actions

- Marshal Hall" first observed the reflex actions.
- The entire process of response to a peripheral nervous stimulation, that occurs involuntarily i.e., without conscious effort or thought and requires the involvement of a part of the central nervous system is called a reflex action.
- Reflex actions are spontaneous, automatic, involuntary, mechanical responses produced by stimulating specific receptors.
- Reflex actions are involuntary actions. Reflex actions are completed very quickly as compared to normal actions. They prevent body from any adverse effect.
- It is form of animal behaviour in which the stimulation of a sensory organ (receptor) result in the activity of some organ without the intervention of will.

Reflex Arc

- The reflex pathway comprises at least one afferent neuron {receptor) and one efferent (effector or excitor) neuron appropriately arranged in a series.
- The afferent neuron receives signal from a sensory organ and transmits the impulse Via a dorsal nerve root into the CNS (at the level of spinal cord).
- The efferent neuron then carries signals from CNS to the effector.
- The path of completion of reflex action is called reflex arc.
- Sensory fibres carry sensory impulses in the gray matter. These sensory impulses are converted now into motor impulses and reach up to muscles. These muscles show reflex actions for motor impulses obtained from motor neurons.

Types Of Reflex Action:

(i) On the basis of site:

(A) Cranial reflex:	(B) Spinal reflex:
(i) These actions are completed by brain. (ii) No urgency is required for these actions. (iii) These are slow actions e.g., watering of mouth to see good food.	(i) These actions are completed by spinal cord. (ii) Urgency is required for these actions. (iii) These are very fast actions e.g., Displacement of the leg at the time of pinching by any needle.

(ii) On the basis of previous experiences:

(A) Conditioned reflex:

Previous experience is required to complete these actions e.g., swimming, cycling, dancing, singing etc. These actions were studied first by Evan Pavlov on dog. Initially these actions are voluntary at the time of learning and after perfection, these become involuntary.

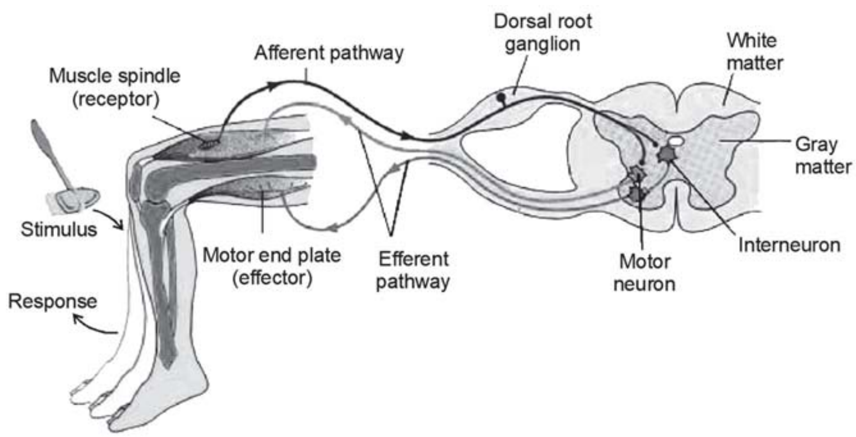
(B) Unconditioned reflex:

These actions do not require previous experience e.g., sneezing, coughing, yawning, sexual behavior for opposite sex partner, migration in birds etc.

(iii) On the basis of synapse:

(A) Monosynaptic:

In this type of reflex arc, there is a direct synapse (relation) found between sensory and motor neurons, thus nerve impulse travels through only one synapse. eg. -Stretch reflex/ Knee-Jerk reflex



Diagrammatic representation of reflex action (Knee Jerk Reflex)

(B) Polysynaptic:

- In this type of reflex arc, there are one or more small neurons found in between the sensory and motor neurons. These small neurons are called connector neuron or inter neurons or internuncial neurons e.g., withdrawal reflex.
- In such synapse nerve impulse will have to travel through more than one synapse.

Structure of Human Eye

The human eye's function based on the fundamental principles akin to those of a camera. Using a single lens, light from all areas of the visual field is concentrated onto a surface of light-sensitive cells. The specific area of the surroundings from which each eye gathers light rays is termed the visual field. The surface of light-sensitive cells is known as the retina, a topic that will be further elaborated upon in the following sections.

The mature human eyeball exhibits an approximately spherical structure. Its wall comprises three concentric layers: the outer layer, referred to as the sclera or fibrous tunic; the middle layer, also known as the uvea or vascular tunic (comprising the choroid and ciliary body or iris); and the innermost layer of the eyeball, called the retina.

Sclera

The sclera is composed of a dense connective tissue, giving it a tough nature. It appears milky or white in color, forming the "white" of the eye, except in the frontal region where it transforms into the transparent cornea. The cornea, a dome-shaped structure, acts as a refracting surface due to its curved form.

As a result, the cornea facilitates the admission of light rays into the eye's interior and bends them to focus. The surface of the cornea is kept moist and free from dust through the secretion from tear glands.

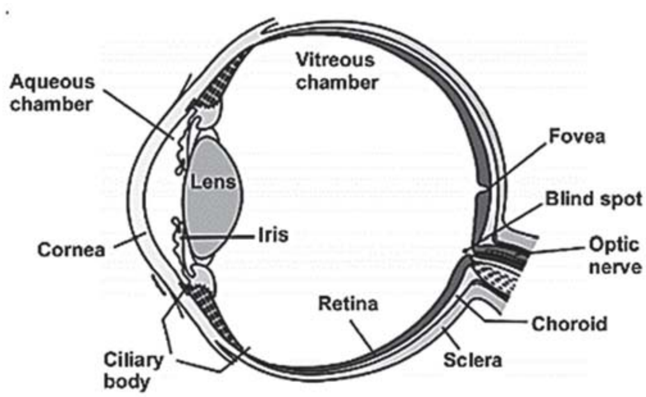


Fig. : Diagram showing parts of an eye

Choroid

The choroid coat, constituting the middle layer of the eyeball, is rich in melanin pigmentation and well-vascularized. Although the choroid appears bluish, it remains hidden from external view as it is covered by the sclera. The primary function of the choroid layer is to prevent the reflection of light rays within the eyes, similar to the purpose served by dull black paint inside a camera.

While the choroid layer is thin over the posterior two-thirds of the eyeball, it thickens in the anterior part to form the ciliary body. The ciliary body extends forward to create the pigmented and opaque iris, which is the visible colored part of the eye, determining the black, brown, green, or blue "color" of the eye. The iris surrounds an opening called the pupil, and the size of the pupil is regulated by the muscle fibers of the iris known as iridial muscle. The diameter of the pupil is variable and under automatic control. In dim light, the pupil enlarges to allow more light into the eye, while in bright light, it narrows down. This not only protects the interior of the eye from excessive illumination but also enhances the image-forming ability and depth of field. Therefore, the iris functions similarly to the 'diaphragm' of a camera, adjusting the pupil's diameter to control the amount of light entering the eye for optimal image sharpness.

Retina

The innermost layer of the eyeball is known as the retina, which houses the light receptors, rods, and cones, functioning akin to the film in a camera. Comprising three layers of cells arranged from the inside out—ganglion cells, bipolar cells, and photoreceptor cells—the retina encompasses two types of photoreceptor cells: rods and cones. These cells contain photopigments, which are light-sensitive proteins.

The retina is comprised of a pigment epithelium (nonvisual portion) and a neural portion (visual portion). The pigment epithelium, a layer of melanin-containing epithelial cells positioned between the choroid and the neural part of the retina, absorbs stray light rays. This absorption prevents the reflection and scattering of light within the eyeball. The continuous pigmented layer covers the choroid, ciliary body, and iris, while the nervous layer terminates just before the ciliary body, denoted as the or a serrata. In albinos, the absence of melanin pigment is observed in all body parts, including the eye.

Rods

Approximately 100 million rods are present in each eye, and they play a crucial role in low-light vision, particularly during twilight conditions (scotopic vision). For effective light absorption, a light-absorbing substance, known as a pigment, is required. In the case of rods, the photopigment is a purplish-red protein called rhodopsin or visual purple. Rhodopsin is integrated into the membranes of rods, resembling the arrangement of chlorophyll pigment molecules in the thylakoids' membranes within chloroplasts, another light-absorbing structure.

Rhodopsin comprises a protein molecule, opsin, linked to a molecule of the carotenoid retinal (an aldehyde of vitamin A). While retinal itself is light orange, its attachment to opsin produces the deep purplish-red color of rhodopsin. When rhodopsin absorbs light, retinal separates from the protein, causing partial bleaching of the rod and generating a nerve impulse simultaneously. The extent of rhodopsin bleaching increases with greater light exposure to the rods. Fortunately, this process is reversible, as some rhodopsin can be resynthesized directly from its breakdown products, retinal and opsin. There is also evidence suggesting the continuous production of fresh retinal in the eye through the oxidation of vitamin A. The body's vitamin A reserves serve as a substantial reservoir for retinal synthesis. Hence, the deficiency of vitamin A is often associated with night blindness, manifested as an inability to see in the dark.

Cones

In contrast to rods, cones are effective only in bright light conditions and are responsible for color vision. Consequently, daylight (photopic) vision and the ability to perceive colors are attributed to cones. The human eye possesses three types of cones, each having characteristic photopigments that respond to red, green, and blue lights. These cone pigments, with retinal as their prosthetic group, are distinct due to variations in the opsin protein to which retinal is attached. The three primary colors are red, green, and blue, and the brain theoretically combines these sensations to generate over 17,000 distinguishable hues recognizable by a well-trained eye.

Cones are categorized into three types: short wavelength-sensitive (blue) cones, medium wavelength-sensitive (green) cones, and long wavelength-sensitive (red) cones. The visual pigments responsible for color vision are erythrosine (sensitive to red), chloropsin (sensitive to green), and cyanopsin (sensitive to blue). In moonlight, where only rods are functional due to low light levels, colors are not perceivable. Various combinations of stimulated cones and their photopigments produce sensations of different colors. Equal stimulation of these cones results in a sensation of white light.

Aqueous and Vitreous Chamber

The interior of the eyeball is partitioned by the iris and lens into two primary chambers. The anterior chamber, situated between the cornea and the lens, is known as the aqueous chamber. Thus, the aqueous chamber defines the space between the cornea and the lens. This chamber is filled with a thin, watery fluid referred to as the aqueous humor, which ultimately drains into the bloodstream. On the other hand, the posterior chamber, located between the lens and the retina, is termed the vitreous chamber. Consequently, the vitreous chamber denotes the space between the lens and the retina. It contains a transparent, semi-solid, gelatinous substance called the vitreous humor, which serves the purpose of supporting the eyeball and is not drained from the eye.

Mechanism of Vision

The eyes capture light rays emitted by various objects, which then enter the eyes either in parallel or diverging forms. Light rays from distant objects ($>$ 6 meters) are parallel upon entering the eyes, while light rays from near objects ($<$ 6 meters) are diverging. In both cases, the light rays need to be refracted to focus on the retina, with greater refraction required for light rays coming from near objects due to their diverging nature. The curved cornea, refractive eye lens, and the eye's humors are responsible for refracting the light rays. The light rays in the visible wavelength are focused on the retina through the cornea and lens, generating impulses in the rods and cones present in the retina.

As mentioned earlier, the photosensitive compounds (photopigments) in rods in human eyes consist of opsin (a protein) and retinal (an aldehyde of vitamin A). Similarly, cone pigments in human eyes are composed of retinal and three different types of proteins (opsins) to which retinals are attached. When light falls on rods and cones, it causes the dissociation of retinal from opsin, resulting in changes in the structure of opsin (remember that this dissociation is a reversible phenomenon). This change in the structure of opsin causes membrane permeability changes, generating potential differences in the photoreceptor cells, i.e., rods and cones. As the photoreceptor cells synapse with the bipolar cells in the next layer, a signal is produced, generating action potentials in the bipolar cells. Bipolar cells then synapse with ganglion cells, leading to action potentials in the ganglion cells through the bipolar cells. In summary, action potentials generated in the photoreceptor cells (due to the breakdown of photopigments) are transmitted to the ganglion cells through the bipolar cells. The axons of the retinal ganglion cells bundle together to form the optic nerve, transmitting these action potentials (impulses) to the visual cortex area of the brain.

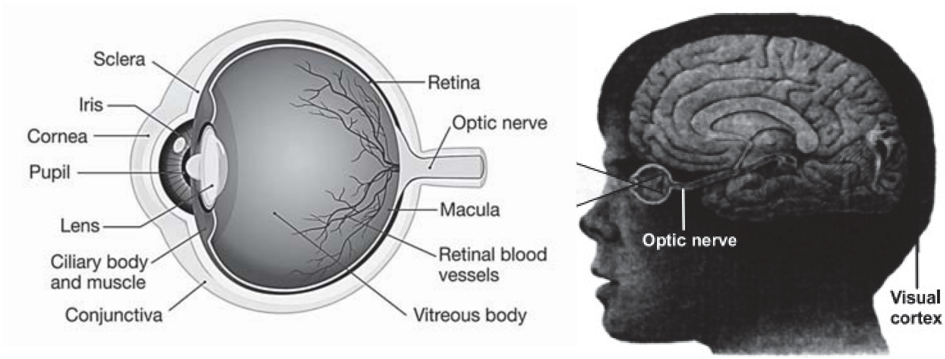


Fig.: Human eye and image formation.

The visual cortex area is situated in the occipital lobes of the cerebrum. Upon reaching the visual cortex area, which is specialized for decoding visual impulses, neural impulses are scrutinized, and the image formed on the retina is recognized. This recognition is influenced by the prior memory and experiences stored in the brain. It is crucial to note in the diagram that the image created by the eye's lens on the retina is both inverted and reversed. Despite this, objects are perceived in the correct orientation due to the brain's interpretation of the images.

Light rays in visible wavelength focused on the retina

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Activation of photopigment of rods and cones

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Light induces dissociation of the retinal form opsin
resulting in the changes in the structure of the opsin.

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Membrane permeability of rods and cones changes.

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Potential difference generated in the photoreceptor cell.

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It generates action potential in the ganglionic cells through the bipolar cells.

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Action potentials are transmitted by the optic nerve to the visual cortex of brain.

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Image formed on the retina is recognised based on earlier memory and experience.