Chapter 5

Sensory, Attentional and Perceptual Processes

After reading this chapter, you would be able to

- understand the nature of sensory processes,
- explain the processes and types of attention,
- analyse the problems of form and space perception,
- examine the role of socio-cultural factors in perception, and
- reflect on sensory, attentional and perceptual processes in everyday life.

The quality of life is determined by its activities.

– Aristotle

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Introduction

In the previous chapters you have already learnt how we respond to various stimuli present in the external and internal environment with the help of our receptors. While some of these receptors are clearly observable (for example, eyes or ears), others lie inside our body, and are not observable without the help of electrical or mechanical devices. This chapter will introduce you to various receptors that collect a variety of information from the external and internal worlds. The focus will be particularly on the structure and function of eye and ear, including some interesting processes associated with vision and audition. You will also know some important things about attention, which helps us to notice and register the information that our sense organs carry to us. Different types of attention will be described along with the factors that influence them. At the end, we will discuss the process of perception that allows us to understand the world in a meaningful way. You will also have an opportunity to know how we are sometimes deceived by certain types of stimuli such as figures and pictures.

Knowing the World

The world in which we live is full of variety of objects, people, and events. Look at the room you are sitting in. You will find so many things around. Just to mention a few, you may see your table, your chair, your books, your bag, your watch, pictures on the wall and many other things. Their sizes, shapes, and colours are also different. If you move to other rooms of your house, you will notice several other new things (e.g., pots and pans, almirah, TV). If you go beyond your house, you will find still many more things that you generally know about (trees, animals, buildings). Such experiences are very common in our day-to-day life. We hardly have to make any efforts to know them.

If someone asks you, "How can you say that these various things exist in your room, or house, or in the outside environment?", you will most probably answer that you see or experience them all around you. In doing so, you are trying to tell the person that the knowledge about various objects becomes possible with the help of our sense organs (e.g., eyes, ears). These organs collect information not only from the external world, but also from our own body. The information collected by our sense organs forms the basis of all our knowledge. The sense organs register several kinds of information about various objects. However, in order to be registered, the objects and their qualities (e.g., size, shape, colour) must be able to draw our attention. The registered information must also be sent to the brain that constructs some meaning out of them. Thus, our knowledge of the world around us depends on three basic processes, called sensation, attention, and perception. These processes are highly interrelated; hence, they are often considered as different elements of the same process, called cognition.

Nature and Varieties of Stimulus

The external environment that surrounds us contains a wide variety of stimuli. Some of them can be seen (e.g., a house), while some can be heard only (e.g., music). There are several others that we can smell (e.g., fragrance of a flower) or taste (e.g., sweets). There are still others that we can experience by touching (e.g., softness of a cloth). All these stimuli provide us with various kinds of information. We have very specialised sense organs to deal with these different stimuli. As human beings we are bestowed with a set of seven sense organs. These sense organs are also known as sensory receptors or information gathering systems, because they receive or gather information from a variety of sources. Five of these sense organs collect information from the external world. These are eyes, ears, nose, tongue, and skin. While our eyes are primarily responsible for vision, ears for hearing, nose for smell, and tongue for taste, skin is responsible for the experiences of touch, warmth, cold, and pain. Specialised receptors of warmth, cold, and pain are found inside our skin. Besides these five external sense organs, we have also got two deep senses. They are called kinesthetic and vestibular systems. They provide us with important information about our body position and movement of body parts related to each other. With these seven sense organs, we register ten different variety of stimuli. For example, you may notice whether a light is bright or dim, whether it is yellow, red or green, and so on. With sound you may notice whether it is loud or faint, whether it is melodious or distracting, and so on. These different qualities of stimuli are also registered by our sense organs.

Sense Modalities

Our sense organs provide us with first-hand information about our external or internal world. The initial experience of a stimulus or an object registered by a particular sense organ is called sensation. It is a process through which we detect and encode a variety of physical stimuli. Sensation also refers to immediate basic experiences of stimulus attributes, such as "hard", "warm", "loud", and "blue", which result from appropriate stimulation of a sensory organ. Different sense organs deal with different forms of stimuli and serve different purposes. Each sense organ is highly specialised for dealing with a particular kind of information. Hence, each one of them is known as a sense modality.

Functional Limitations of Sense Organs

Before we move on to a discussion of sense organs, it is important to note that our sense organs function with certain limitations. For example, our eyes cannot see things which are very dim or very bright. Similarly our ears cannot hear very faint or very loud sounds. The same is true for other sense organs also. As human beings, we function within a limited range of stimulation. For being noticed by a sensory receptor, a stimulus has to be of an optimal intensity or magnitude. The relationship between stimuli and the sensations they evoke has been studied in a discipline, called **psychophysics**.

In order to be noticed a stimulus has to carry a minimum value or weight. The minimum value of a stimulus required to activate a given sensory system is called **absolute threshold** or **absolute limen** (AL). For example, if you add a granule of sugar to a glass of water, you may not experience any sweetness in that water. Addition of a second granule to water may also not make it taste sweet. But if you go on adding sugar granules one after another, there will come a point when you will say that the water is now sweet. The minimum number of sugar granules required to say that the water is sweet will be the AL of sweetness.

It may be noted at this point that the AL is not a fixed point; instead it varies considerably across individuals and situations depending on the people's organic conditions and their motivational states. Hence, we have to assess it on the basis of a number of trials. The number of sugar granules that may produce the experience of "sweetness" in water on 50 per cent of occasions will be called the AL of sweetness. If you add more number of sugar granules, the chances are greater that the water will be reported more often as sweet than plain.

As it is not possible for us to notice all stimuli, it is also not possible to differentiate between all stimuli. In order to notice two stimuli as different from each other, there has to be some minimum difference between the value of those stimuli. The smallest difference in the value of two stimuli that is necessary to notice them as different is called **difference threshold** or **difference limen** (DL). To understand it, we may continue with our "sugar water" experiment. As we have seen, the plain water is experienced as sweet after the addition of certain number of sugar granules. Let us remember this sweetness. The next question is: how many sugar granules will be needed in the water in order to experience its sweetness as different from the previous sweetness. Go on adding sugar granules one after another tasting the water each time. After addition of a few granules, you will notice at a point that the water is now sweeter than the previous one. The number of sugar granules added to the water to generate an experience of sweetness that is different from the previous sweetness on 50 per cent of the occasions will be called the DL of sweetness. Thus, difference threshold is the minimum amount of change in a physical stimulus that is capable of producing a sensation difference on 50 per cent of the trials.

You may realise by now that understanding of sensations is not possible without understanding the AL and DL of different types of stimuli (for example, visual, auditory), but that is not enough. Sensory processes do not depend only on the stimulus characteristics. Sense organs and the neural pathways connecting them to various brain centers also play a vital role in this process. A sense organ receives the stimulus and encodes it as an electrical impulse. For being noticed this electrical impulse must reach the higher brain centers. Any structural or functional defect or damage in the receptor organ, its neural pathway, or the concerned brain area may lead to a partial or complete loss of sensation.

Visual Sensation

Among all sense modalities, vision is the most highly developed in human beings. Various estimates indicate that we use it in approximately 80 per cent of our transactions with the external world. Audition and other senses also contribute significantly to information gathering from the external world. We shall discuss vision and audition in some detail. The main features of other senses can be found in Box 5.1.

Visual sensation starts when light enters the eyes and stimulates our visual receptors. Our eyes are sensitive to a spectrum of light, the wavelength of which ranges from 380 nm to 780 nm (nm refers to nanometer, which is one billionth of a meter). No sensation is registered beyond this range of light.

The Human Eye

A diagram of the human eye is shown in Figure 5.1. As you can see, our eye is made up of three layers. In the outer layer, there is a transparent **cornea** and a tough **sclera** that surrounds the rest of the eye. It protects the eye and maintains its shape. The middle layer is called **choroid**, which is richly supplied with blood vessels. The inner layer is known as **retina**. It contains the photoreceptors (rods and cones) and an elaborate network of interconnecting neurons.

The eye is generally compared with a camera. For example, the eye and camera have a lens. The **lens** divides the eye into two unequal chambers, namely **aqueous chamber** and **vitreous chamber**. The aqueous chamber is located between the cornea and the lens. It is smaller in size and is filled with a water-like substance, called **aqueous humor**. The vitreous chamber is located between the lens and the retina. It is filled with a jelly like protein, called **vitreous humor**. These fluids help in holding the lens at its appropriate place and in proper shape. They also allow enough flexibility for the occurrence of accommodation — a process through which the lens changes its shape in order to focus the objects at varying distances. This process is regulated by **ciliary muscles**, which are attached to the lens. These muscles flatten the lens to focus the distant objects and thicken it to focus the near objects. Like a camera, the eye also has a mechanism to control the amount of light

Box 5.1 Other Human Senses

Besides vision and audition, there are other senses that enrich our perceptions. For example, an orange looks attractive not only because of it is colour but also because it has got a special flavour and taste. These other senses are briefly described here.

1. ***Smell** : The stimulus for smell sensation consists of molecules of various substances contained in the air. They enter the nasal passage where they dissolve in moist nasal tissues. This brings them in contact with receptor cells contained in olfactory epithelium. Human beings possess about 50 million of these receptors, whereas dogs possess more than 200 million of these receptors. Nevertheless, our ability to detect smell is impressive. It is indicated that human beings can recognise and distinguish among approximately 10,000 different odours. The sense of smell also shows sensory adaptation like other senses.*
2. ***Taste** : The sensory receptors for taste are located inside small bumps on the tongue, known as papillae. In each papilla there is a cluster of taste buds. Human beings possess almost 10,000 taste buds. While people claim to distinguish a large number of flavours in food, there are only four basic tastes, namely sweet, sour, bitter and salty. How is it then that we perceive many more? The answer is that we are aware not only of the taste of the food, but also of its smell, its texture, its temperature, its pressure on our tongue, and many other sensations. When these factors are removed, we are left with only four basic tastes. Besides, the combination of different flavours in varied proportions results in a different kind of flavour which may be quite unique.*
3. ***Touch and other skin senses** : Skin is a sensory organ that produces sensations of touch (pressure), warmth, cold, and pain. In our skin there are specialised receptors for each one of these sensations. The receptors of touch are not evenly distributed in our skin. That is why some areas of our body (e.g., face, fingertips) are more sensitive than others (e.g., legs). Pain sensation has no specific stimulus. Hence, determining its mechanism has been fairly difficult.*
4. ***The Kinesthetic system** : Its receptors are found primarily in joints, ligaments, and muscles. This system gives us information about the location of our body parts in relation to each other, and allows us to perform simple (e.g., touching one's nose) and complex movements (e.g., dancing). Our visual system provides a great deal of help in this respect.*
5. ***The Vestibular system** : This system gives us information about our body position, movement, and acceleration — the factors that are critical for maintaining our sense of balance. The sensory organs of this sense are located in the inner ear. While vestibular sacs inform us of our body positions, the semicircular canals inform us about our movements and acceleration.*

entering into it. The **iris** serves this purpose. It is a disc-like coloured membrane lying between the cornea and the lens. It controls the amount of light entering the eye by regulating pupil dilation. In dim light the pupil dilates; in bright light it contracts.

Retina is the inner most layer of an eye. It is made up of five types of photosensitive cells among which rods and cones are most important. **Rods** are the receptors for scotopic vision (night vision). They operate at low intensities of light, and lead to achromatic (colourless) vision. **Cones** are the receptors for photopic (day light) vision. They operate at high levels of illumination, and lead to chromatic (colour) vision. Each eye contains about 100 million rods and about 7 million cones. The cones are highly concentrated in the central region of the retina surrounding the **fovea**, which is a small circular region of the size of a pea. It is also known as the **yellow spot**. It is the region of maximum visual acuity. Besides photoreceptors, retina also contains a bundle of axons of a cell (called ganglion cell) that forms the **optic nerve**, which leads to the brain.

Working of the Eye

Passing through conjunctiva, cornea, and pupil, the light enters the lens, which focuses

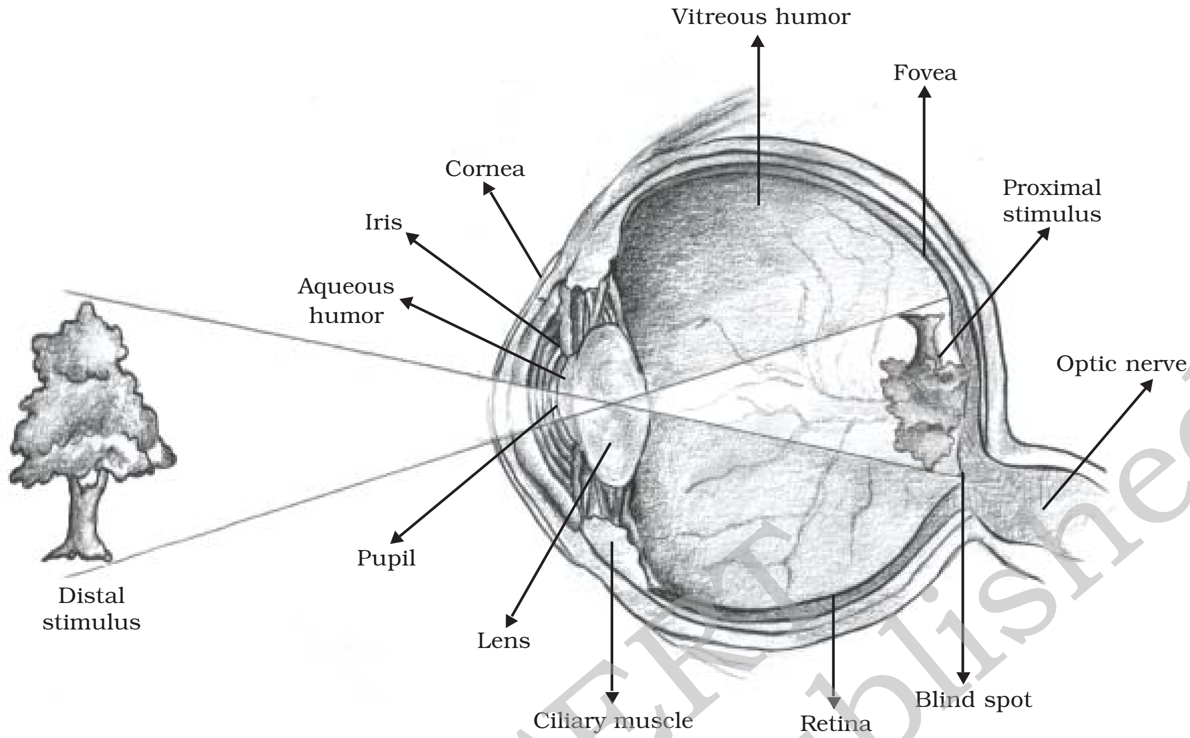

Fig.5.1 : Structure of the Human Eye

it on to the retina. Retina is divided into two parts: the nasal half and the temporal half. The inner half portion of the eye (towards the nose), taking the center of fovea as mid-point, is called the nasal half. The outer half portion of the eye (towards the temple) from the center of fovea is called the temporal half. Light from the right visual field stimulates the left half of each eye (i.e. the nasal half of the right eye and the temporal half of the left eye), and light from the left visual field stimulates the right half of each eye (i.e. the nasal half of the left eye and the temporal half of the right eye). An inverted image of the object is formed on the retina. The neural impulse is transmitted to the visual cortex through the optic nerve where the image is re-inverted and processed. You can see in Fig.5.1 that the optic nerve leaves the retina from the area that has no photoreceptors. In this area visual sensitivity is completely absent. Therefore, it is called the **blind spot**.

Adaptation

The human eye can function at a very large range of light intensities. Sometimes we have to undergo a rapid change in illumination levels. For example, when we go to a matinee show movie, we find it difficult to see things in the hall on entering into it. However, after spending about 15 to 20 minutes there, we are able to see everything. After the show when we go out into the open, we find the light outside the hall too bright to see things, or sometimes even to keep our eyes open. However, within a minute or so we feel comfortable, and are able to see things properly. This adjustment is faster than the one made on entering the hall. The process of getting adjusted to different intensities of light is called 'visual adaptation'.

Light adaptation refers to the process of adjusting to bright light after exposure to dim light. This process takes nearly a minute or two. On the other hand, **dark adaptation**

refers to the process of adjusting to a dimly illuminated environment after exposure to bright light. This may take half an hour or even longer depending on the previous level of exposure of the eye to light. There are certain ways in which these processes can be facilitated. An interesting activity is given below to demonstrate this process to you.

Activity 5.1

Move from a lighted area to a dark room and note how much time you take to see things clearly in that room.

Next time put on red goggles while you stay in the lighted place. Then move into the dark room and note how much time you take to see things clearly in that room.

You will notice that the use of red goggles has greatly reduced the time required for dark adaptation.

Do you know why has this happened? Discuss with your friends and the teacher.

Photochemical Basis of Light and Dark Adaptation : You may wonder why the light and dark adaptations take place. According to the classical view, light and dark adaptations occur due to certain photochemical processes. The rods have a photo-sensitive chemical substance, called **rhodopsin** or visual purple. By the action of light the molecules of this chemical substance get bleached or broken down. Under such conditions the light adaptation takes place in the eyes. On the other hand, the dark adaptation is achieved by the removal of light, and thereby allowing for restorative processes to regenerate the pigment in the rods with the help of vitamin A. The regeneration of rhodopsin in rods is a time consuming process. That is why dark adaptation is a slower process than light adaptation. It has been found that people who suffer from vitamin A deficiency do not achieve dark adaptation at all, and find it really difficult to move in the dark. This condition is generally known as night blindness. A parallel chemical believed to be found in cones is known as *iodopsin*.

Colour Vision

In our interaction with the environment we not only experience a variety of objects, but also their colours. It may be noted that colour is a psychological property of our sensory experience. It is created when our brain interprets the information received from the external world. It may be remembered that light is described physically in terms of wavelength, not in terms of colour. As we have read earlier, the visible spectrum is a range of energy (380-780 nm) that our photoreceptors can detect. The energy lower or higher than the visible spectrum is harmful to the eyes. The sun light is a perfect mixture of seven colours just like a rainbow. The colours observed are violet, indigo, blue, green, yellow, orange, and red, abbreviated as 'VIBGYOR'.

The Dimensions of Colour

A person with normal colour vision can distinguish more than seven million different shades of colour. Our experiences of colour can be described in terms of three basic dimensions, called hue, saturation, and brightness. **Hue** is a property of chromatic colours. In simple words, it refers to the name of the colour, e.g., red, blue, and green. Hue varies with wavelength, and each colour is identified with a specific wavelength. For example, blue has a wavelength of about 465 nm, and green of about 500 nm. Achromatic colours like black, white or grey are not characterised by hues. **Saturation** is a psychological attribute that refers to the relative amount of hue of a surface or object. The light of single wavelength (monochromatic) appears to be highly saturated. As we mix different wavelengths, the saturation decreases. The colour grey is completely unsaturated. **Brightness** is the perceived intensity of light. It varies across both chromatic and achromatic colours. White and black represent the top and bottom of the brightness dimension. White has the highest degree of brightness, whereas black has the lowest degree.

Colour Mixtures

There is an interesting relationship among colours. They form complementary pairs. When mixed in correct proportions the complementary colours yield an achromatic grey or white. Examples of complementary colours are red-green and yellow-blue. Red, green and blue are called **primary colours**, because on mixing, the light of these three colours can produce almost any colour. The most common example is the television screen. It contains spots of blue, red and green colours. The combinations of these three produce different colours and shades that we see on the TV screen.

After Images

This is quite an interesting phenomenon related to visual sensations. The effect of a visual stimulus persists for some time even after the removal of that stimulus from the visual field. This effect is called after image. After images are positive and negative. **Positive after images** resemble the original stimulus in terms of hue, saturation, and brightness. They usually occur after a brief intense stimulation of dark adapted eyes. On the other hand, **negative after images** appear in complementary colours. These images appear when a person stares at the patch of a particular colour for at least 30 seconds, and then transfers the gaze to a neutral background (e.g., a white or grey surface). If the person looks at the blue colour, the negative after image will appear in yellow. Similarly, a red stimulus will yield a negative after image of green colour.

Auditory Sensation

Audition or hearing is also an important sense modality that carries great value for us. It provides us with reliable spatial information. Besides orienting us to certain objects or individuals, it plays a vital role in spoken communication also. Auditory sensation begins when sound enters our ear and stimulates the chief organs of hearing.

The Human Ear

Ear is the primary receptor of auditory stimuli. While its well-known function is hearing, it also helps us in maintaining our body balance. The structure of an ear is divided into three segments, called the external ear, the middle ear, and the inner ear (Fig.5.2).

External Ear: It contains two main structures, namely *pinna* and *auditory meatus*. Pinna is a cartilaginous funnel-shaped structure that collects sound waves from the surroundings. Auditory meatus is a canal protected by hair and wax that carries sound waves from pinna to the *tympanum* or *ear drum*.

Middle Ear : The middle ear starts with *tympanum*, a thin membrane highly sensitive to sound vibrations. This is followed by the *tympanic cavity*. It is connected to the pharynx with the help of **Eustachian tube**, which maintains the air pressure in tympanic cavity. From the cavity the vibrations pass to three ossicles known as *malleus* (hammer), *incus* (anvil), and *stapes* (stirrup). They increase the intensity of sound vibrations about 10 times, and send them to the inner ear.

Inner Ear : The inner ear has a complicated structure known as *membranous labyrinth*, which is encapsulated in a bony shell called *bony labyrinth*. A lymph-like fluid is found in the space between bony labyrinth and membranous labyrinth. This is called *perilymph*.

The bony labyrinth has three **semi-circular canals** at right angle to each other, a cavity, called **vestibule**, and a coiled structure, called **cochlea**. The semicircular canals have fine hair cells, which are highly sensitive to postural changes as well as changes in the body orientation. Inside the bony cochlea, there is a membranous cochlea, which is also known as **scala media**. It is filled with endolymph, and has a spirally coiled membrane, called **basilar membrane**. It has got fine hair cells arranged in a series to form the **organ of corti**. This is the main organ for hearing.

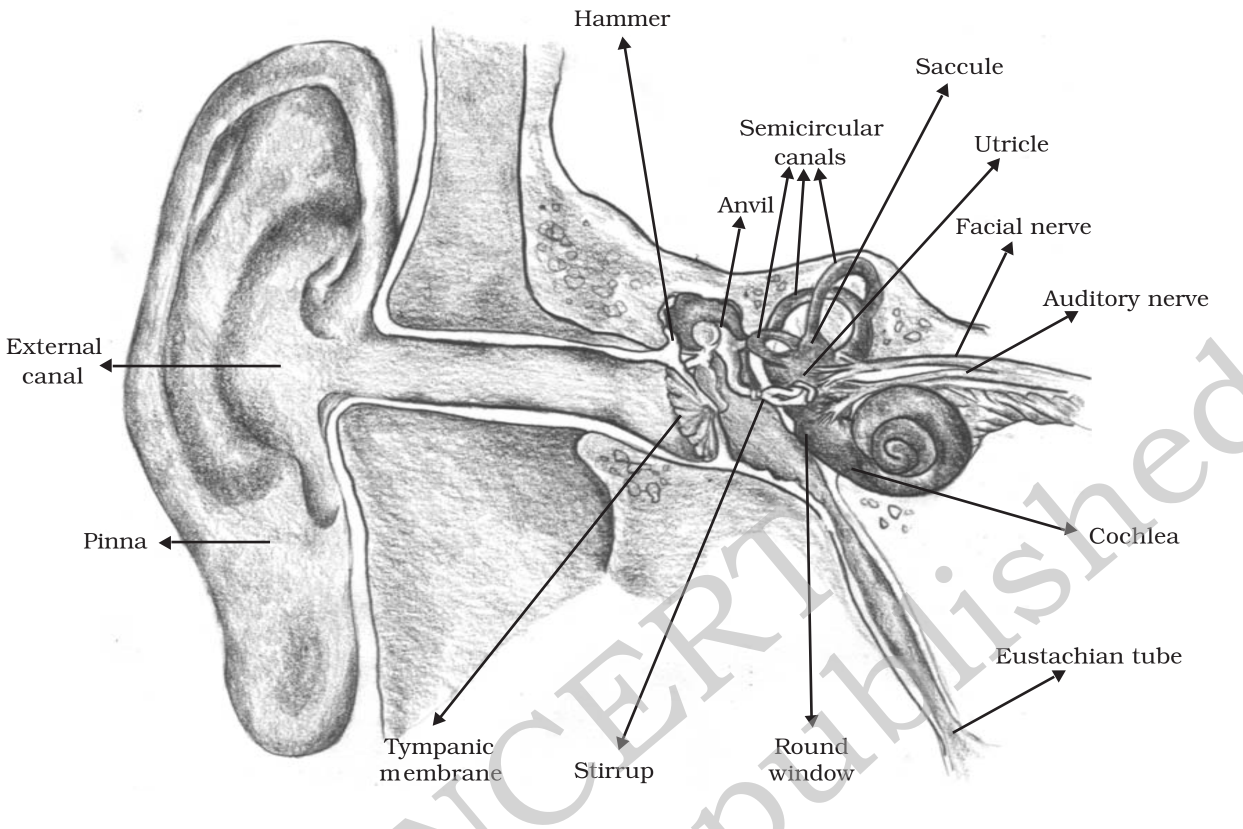

Fig.5.2 : Structure of the Human Ear

Working of the Ear

Pinna collects the sound vibrations and serves them to the tympanum through the auditory meatus. From the tympanic cavity the vibrations are transferred to the three ossicles, which increase their strength and transmit them to the inner ear. In the inner ear the cochlea receives the sound waves. Through vibrations the endolymph is set in motion, which also vibrates the organ of corti. Finally, the impulses are sent to the auditory nerve, which emerges at the base of cochlea and reaches the auditory cortex where the impulse is interpreted.

Sound as a Stimulus

We all know that sound is the stimulus for ears. It results from pressure variations in the external environment. Any physical movement disturbs the surrounding medium (i.e. air), and pushes the air molecules back and forth. This results in changes in pressure that spread outward in the form of sound waves, travelling at a rate of about 1,100 ft/sec. These changes travel in waves much like the ripples set up by a stone thrown into a pond. When these sound waves strike our ears, they initiate a set of mechanical pressure changes that ultimately trigger the auditory receptors.

The simplest kind of sound wave is one that causes successive pressure changes over time in the form of a single repeating sine wave (Fig.5.3). Sound waves vary in amplitude as well as in wavelength. **Amplitude** is a general measure of stimulus magnitude. It is the amount of change in pressure, i.e. the extent of displacement of the molecules from the position of rest. In Fig.5.3 the amplitude of sound wave is represented as the distance of